THE
PHYSICAL ATLAS
OF
NATURAL PHENOMENA

JOHNSTON

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THE
PHYSICAL ATLAS

A SERIES OF MAPS & ILLUSTRATIONS

OF THE

Geographical Distribution

OF

NATURAL PHENOMENA

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I GEOLOGY. II HYDROGRAPHY.

III METEOROLOGY. IV NATURAL HISTORY.

BY

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WITH THE CO-OPERATION

OF MEN EMINENT IN THE DIFFERENT DEPARTMENTS

OF SCIENCE.

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TO

HIS EXCELLENCY

THE

BARON ALEXANDER VON HUMBOLDT,

AT WHOSE SUGGESTION THIS WORK WAS ORIGINALLY UNDERTAKEN,

AND ON WHOSE PROFOUND AND VARIED RESEARCHES

IN EVERY DEPARTMENT OF NATURAL SCIENCE

A LARGE PORTION OF THE CONTENTS IS FOUNDED,

THIS VOLUME

IS MOST RESPECTFULLY AND GRATEFULLY

INSCRIBED.

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PREFACE.

In this Atlas it has been attempted to present in a graphic form, a concise yet comprehensive view of the Physical Geography of the Globe, embracing under that term its superficial structure, the movements of its oceanic and aerial currents, and the distribution of organized existence on its surface.

The importance and utility of this most interesting branch of knowledge, and the absence in this country of the necessary aids for its study, induced the Editor to undertake the supply of a felt desideratum by the production of a series of Maps and other illustrations of Natural Phenomena, considered in their mutual relations and dependencies, on a scale worthy of the subject, and which, with descriptive letter-press, should be in keeping with the rapid progress and marked development in every other branch of science at the present day. In pursuance of this design, the Editor visited the principal geographical establishments on the Continent of Europe in 1842, and on that occasion entered into copy-right arrangements with Professor Berghaus of Potsdam for the publication of a certain portion of his celebrated Physikalischer Atlas. Four sheets of that work, greatly extended and improved, were appended to the "National Atlas" in 1843.

These were announced as specimens of a larger work to be immediately proceeded with, should such be demanded; and encouraged by the flattering manner in which they were received, and urged by solicitations for their continuance from many of the most influential scientific men of this and other countries, the Editor was induced to commence the construction of a complete Physical Atlas. The five intervening years have been devoted, unremittingly, to the elaboration of materials previously collected, and to researches necessary for their due arrangement. Of the thirty Maps comprised in the Work, fifteen were designed by Professor Berghaus, and are now produced on an enlarged scale, with many additions. For the construction of the others the Editor is alone responsible; for although some of them were suggested by the Maps of Professor Berghaus, they are so different in construction, in extent of scale, and in amount of matter, as to constitute them in reality original works. This will at once be seen by comparing the corresponding subjects in the German and English publications.

In the letter-press descriptions, the Editor has endeavoured to present a careful synopsis, from original sources, of every subject treated of in the Maps, and he ventures to hope that this department of his labours will be found to embody a complete digest of Physical Geography; but, in all cases, he has made constant reference to the best authorities for more extensive information.

The Atlas is arranged under the following heads:—

GEOLOGY.
HYDROLOGY.
METEOROLOGY.
PHYTOLOGY AND ZOOLOGY.

Each division is adjusted and printed so as to be complete in itself, and, at the same time, a component part of the whole Work.

The Editor embraces this opportunity of expressing his deep obligations to the Baron Alexander von Humboldt, at whose suggestion the Work was undertaken, on whose researches a large portion of its contents has been based, and who has repeatedly, during its progress, honoured it with his approbation. He has also to offer his acknowledgments to those gentlemen who have enriched the Volume with the valuable contributions to which their names are appended, and to many other scientific and literary friends who have favoured him with encouragement and advice.

ALEXANDER KEITH JOHNSTON.

Edinburgh, *April*, 1848.

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THE MOUNTAIN SYSTEMS OF EUROPE.

CONSTRUCTED ON THE BASIS OF

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ACCORDING TO OLSEN'S MAP, AND THE INVESTIGATIONS OF AMI BOUÉ IN TURKEY, MARMARA IN SARDINIA, &c.

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INTRODUCTION.

The first attempt to construct an orographic plan, on the basis of level or contour lines, was made by M. Dupin Triel on a Map of France, entitled "New Method of Expressing Altitudes on Maps, with a Memoir by M. Du Carla," published at Paris in 1784.[1] "If," says the latter, "we join together by one line all the points which, on a marine Chart, are marked with equal soundings, the contour of such line will be that of a section made at the bottom of the sea, on a horizontal plane, sunk below the surface of the water to an extent equal to the number of fathoms contained in the soundings." Reversing this process, by rising above the surface of the sea instead of descending below it, and proceeding on similar data, he proposed to represent, geometrically, the configuration of the surface of a country. The method consists in tracing on a Map all the lines which pass through points placed on the same level, or at the same height above the mean surface of the ocean; which lines would successively become the margin of the sea, if it were by any means raised to the position where they are placed, in the same manner as the lines which join the soundings of equal depth would form its shores, if it were lowered to the number of fathoms marked in the soundings.

The space between these lines, or horizontal sections of the earth, must be graduated according to the scale of the Map and the nature of the country to be represented. Where this is flat, the lines will be placed at wide intervals; and in proportion as the country rises, they will gradually approach each other. Plateaux or table-lands are defined by the lines of level which surround them. Thus, if we conceive lines so placed as to cut these contours at right angles, we have the lines of greatest declivity, or those in which water descends from the tops of mountains; because lines cutting the contours at *right angles* descend directly down the mountain side, and are steeper than those making circuitous slopes around its sides. The system of contouring is now fully appreciated, and its general introduction on Maps of our own country has been ably advocated by men of eminent scientific attainments. At the meeting of the British Association for the Advancement of Science, held at Cork in 1843, Captain Larcom and Dr Robinson of Armagh strenuously urged its continued use on the Maps of the Trigonometrical Survey of Ireland.[2] In a valuable paper on Trigonometrical Surveying, published in the "Quarterly Journal of Agriculture" for February 1844, Mr Galbraith has shown the importance of its application to the survey of Scotland now commenced; and Captain Vetch, in his evidence before the Parliamentary Committee of Inquiry into the state of large towns and populous districts, has clearly demonstrated the advantages of the system when applied to the survey of towns.

["The question how high a mountain is, and the wish to see this question answered on a Map, is so natural, that the neglect which chorographic preparations of Hypsometry has experienced would be surprising, if we did not consider that, till very recently, the number of measurements of heights in the great mountain systems of Europe only amounted to a few hundreds. Thence Dupin Triel's work could only be a very rough attempt, founded on many vague assumptions. About the beginning of the nineteenth century Hypsometry first assumed its proper place. With the completion of barometrical formulæ, through Ramond and Laplace, together with the more accurate construction of the mercurial measuring tube or mountain barometer, and its safe portability (of which Alexander Von Humboldt's journey in the New World had given so fine an example), arose the desire to prosecute hypsometrical inquiries. The result of these, in connection with geodetical measurements of height, have, during the last thirty years, furnished sufficient materials for the construction of an orographic plan, exhibiting at one view the height of the mountain chains, table-lands, isolated hills, river valleys, and the principal dwelling-places of men. Often had the great merit of collecting, sifting, and arranging these materials, and employing them in an orographic representation of the whole of Europe (with the exception of Eastern Russia), which, indeed, leaves little to be desired. This appeared, with Brodsdorff's assistance, in the year 1824, in consequence of the Geographical Society of Paris having made the Orography of Europe the subject of a prize; it was afterwards extended and improved, in the years 1828–33, and published in a complete form during the latter year at Copenhagen. The author had, in the year 1821, prepared a Physical Map of France, and subsequently continued diligently to collect the requisite data for an analogous, though more extended, representation of Germany and the neighbouring countries, supplying the existing blanks in these elements by measurements and barometrical observations of his own. He was, therefore, agreeably surprised, twelve years afterwards, by Oken's Ewachy gen of a copy of his work, from which it was evident that these labours had not been without value; for what he had collected, measured, and published in the Hertha,[3] was not only recognised by Olsen, but, as the commentary to his Map shows, were very frequently consulted. It has been thought necessary to give this historical notice, in order that the reader might be placed in a proper position for the examination of the accompanying Sheet."—D.T.]

Further information on this beautiful and simple method of delineation will be found in the following treatises:—Instructions données en 1818 aux Ingénieurs Géographes, par l'Administration du Dépôt de la Guerre. Paris.—Traité de Topographie d'Arpentage et de Nivellement. Par. L. Puissant. P. 226. Paris: 1820.—Précis de la Géographie Universelle. Par Malte-Brun et Huot. Tome ii., p. 169. Paris: 1832.—Report of Proceedings of British Association for the Advancement of Science, held at Cork: 1843.—Highland Society's Journal of Agriculture. Edinburgh: 1844.—Journal of the Royal Geographical Society of London, vol. xiv., p. 58.—Practical Geodesy. By Butler Williams. London: 1842.—And Edinburgh New Philosophical Journal, January, 1845.

DESCRIPTION OF THE MAP.

I.—PERPENDICULAR EXTENT OF MOUNTAINS AND TABLE-LAND.

The Map represents, according to the materials furnished by the above-named authorities, a view of the principal Mountain Systems of Europe, laid down to accurate scale, on the plan of *normal* contours. The first, or lowest series of lines, indicate an elevation of 500 feet above the mean level of the ocean; and all the others 1000 feet each in succession, beginning at the sea-shore, and terminating in *Mont Blanc*, the culminating point of Europe. The small scale on which this Map is projected renders it difficult to discriminate the line of level; and hence, it can only be regarded as affording a general view of the mountains and valleys of Europe, on a principle of construction which, to be effective, must be projected on a very large scale.

II.—HORIZONTAL AREAS.

These are accurately indicated, by the adoption of varied depths of shading—the object being to produce, by means of hatched lines, such a relief of the ground as to give the effect of a reduced model of the country.

III.—MOUNTAIN RANGES.

In order to preserve the distinctness of the orographic features of the Map, the names of the great mountain chains are omitted, and those of separate mountain peaks, villages, &c., are abbreviated; but the following Abstract of the principal Mountain Systems, and the Table of Abbreviations, will, it is hoped, supply the omissions:—

Names of Ranges.	Position and Extent.	Culminating Points.	Heights.
THE ALPS	Form the highest and most extensive mountain system of Europe (except the Caucasus, which belongs in common to Europe and Asia); and extend, in length, from the Valley of the Rhone on the west to that of the Narenta on the east, occupying the space from about 5° to 16° east longitude,* and 44° to 48° north latitude.	Mont Blanc.	15,810 feet.
THE PYRENEES	Extend, in the widest sense of the term, from the Mediterranean Sea to the Bay of Biscay, forming a natural barrier between France and Spain; but, as more commonly understood, the chain is confined to the space between 42° 10′ and 43° 20′ north latitude, and 1° 20′ east to 1° 40′ west longitude, or from Cape Creus to Bayonne.	Pic Nethou (Maladetta).	11,169 „
THE CARPATHIAN MOUNTAINS, OR KRAPACKS.	Constitute the north-eastern portion of the mountain system of Southern Europe, extending in a regular curve from the Danube, at Presburg, to the borders of Silesia, between Galicia and Hungary, Transylvania and Wallachia, terminating at Orsova in Banat.	Lomnitz Peak, in the Tatra Group.	8,779 „
MOUNTAINS OF TURKEY.	The mountains of this peninsula do not form any connected system. The principal chains in Turkey are, the Balkhan (ancient Hæmus), on the north; the Despoto Dagh (ancient Rhodope), on the south; and the Itharic Alps, on the north-west (M. Dinaric, 6,000.)	Tarbar Dagh.	10,000 „
MOUNTAINS OF GREECE.	Mount Olympus, an eastern offset of the Pindus chain, is the highest point in Greece. The other mountains are, Mount Zagora or Helicon, Mounts Parnassus, Parnes, Pentelicus, and Hymettus.	Mount Olympus.	9,759 „
THE APENNINES	Form the great mountain system of Italy. The range is connected with the Alps at about 8° east longitude, and traverses the whole peninsula, terminating at the Straits of Messina.	Monte Corno.	9,828 „
THE SCANDINAVIAN SYSTEM.	The chain of mountains called the Scandinavian Alps, extend across the Peninsula of Scandinavia, from north-east to south-west, separating, in their northern division, Norway from Sweden. In the southern division, they take successively the names of Dovre-field, Lang-field, Sogne-field, and Hardanger-field.	Snee Hatten, in the Dovre-field.	8,722 „
THE HESPERIAN SYSTEM	Is so called because it comprehends all the mountains and plateaux of the ancient Hesperia, now the kingdoms of Spain and Portugal. The principal ranges are—the Cantabrian Range, a continuation of the Pyrenees; the Carpitan Range, from the Monts de Arez to Cape Roca (culminating point of the Sierra de Guadarrama); the Andalusian Range, from Cape St Antonio to Cape St Vincent, including the Sierra Morena, and the Range of Granada, with the Sierra Nevada and its culminating point, the Cerro Malhacen.	Cerro Malhacen.	11,660 „
MOUNTAINS OF FRANCE.	These form a large group in the southern parts of the country. The eastern portion from north to south constitutes a long belt, in connection with the mountains of Western Germany, to the vicinity of the Weser. The principal ranges are the Cevennes, the Volcanic System of Auvergne, the mountains of Charolais, the Vosges, and the great Plateau of the Nether Rhine (Ardennes, Eifel, Hundsrück, Westerwald, &c.	Pic de Sancy.	6,222 „
THE MOUNTAINS OF GERMANY	Form two distinct systems, the one ranging from south-east to north-west, the principal groups of which are, the Fichtel-gebirge, in the middle; the Erzgebirge, forming the boundary between Saxony and Bohemia, with its eastern branch, the Sudeten-gebirge. The Bohmer Wald Mountains separating Bohemia from Bavaria, and the Harz Mountains forming the northern limit of the Thuringian Plateau. The second system in the direction from south to north, contains, on the one hand, the Schwarzwald and the Odenwald mountains, Spessart and Rhön; and, on the other, the long range of the German Jura, from the Rhine to the Main.	Schnee Koppe, in the Riesen-gebirge.	5,000 „
MOUNTAINS OF SCOTLAND.	The chain of the Grampian Mountains, separating the Highlands from the Lowlands of Scotland, is the most extensive in Britain. The other ranges proceeding from south to north, are the Solway Hills, the Ochils, the Pentlands, and the Cheviot Hills, which separate Scotland from England.	Ben Nevis.	4,362 „
MOUNTAINS OF ENGLAND.	The mountains of Wales, or the Cambrian System, are the highest in England.	Snowdon.	3,571 „
MOUNTAINS OF IRELAND.	In Ireland, the principal range of mountains extends across the south-western part of the island from east to west.	Carn Tual, in Magillicuddy's Reeks.	3,410 „

[1] The idea originated with Ph. Buache, when observing the successive intersections made by a receding or rising tide, on the plain of the surface of the sea, on a vertical coast. He and others proposed the adoption of normal contours for marking lines of equal soundings on marine Charts.—See *Mémoires de l'Académie des Sciences*: 1752, p. 399; 1755, p. 594; and 1760, p. 399.

[2] The system of normal contours was adopted in the Irish survey in 1839, but suspended at the time referred to above.

[3] A monthly geographical publication, by Dr Berghaus.

* The longitude throughout is calculated from Greenwich.

THE MOUNTAIN SYSTEMS OF EUROPE

CONSTRUCTED ON THE BASIS OF CONTOUR LINES

From the DRAWINGS OF PROFESSOR BERGHAUS, Berlin.

BY A.K. JOHNSTON, F.R.G.S.

Geographical Miles 60 to a Degree

English Miles 69 to a Degree

NORTH SEA OR GERMAN OCEAN

BALTIC SEA

Gulf of Bothnia

Gulf of Finland

Gulf of Riga

Lake Ladoga

Skagerrack

Kattegat

Irish Sea

St George's Channel

English Channel

BAY OF BISCAY

MEDITERRANEAN SEA

ADRIATIC SEA

IONIAN SEA

BLACK SEA

Sea of Azof

Archipelago

ASIA MINOR

Sicily

Sardinia

Corsica

Crete

Malta

Faröer

Shetland Islands

Orkney I.

Gulf of Gothland

Gothland I.

Oland I.

Bornholm I.

Rugen I.

Aland I.

Oesel I.

Western Isles

Strait of Bonifacio

Longitude West from Greenwich

Longitude East from Greenwich

EXPLANATION

This Map is based chiefly on the orography of Europe by Berghaus & Olsen, except the Mountain Chains in Turkey & Greece which are corrected according to the observations & measurements of Boué and those of Sardinia, which are given according to Marmora.

The Contour Lines or lines of equal height, each of which indicates an elevation of 1000 feet are represented by a continuous streke thus ———. The lines indicating 500 feet elevation by an interrupted line thus – – – Undetermined portions of both are expressed in broken lines thus – – – or thus . . . . .

NOTE

In order not to obscure the orographic features of the Map, the names of the Great Mountain Chains are omitted, and those of single groups Points, Villages &c are in general contracted. An alphabetical list of these contractions is given in the accompanying letterpress.

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

ALPHABETICAL LIST OF ABBREVIATIONS, WITH THEIR EXPLANATIONS.

A

Am. . . . Amsey (West Alps).
As. . . . Asiago (South Alps).
Aal. . . . Aalen (Swabian Jura).
Alb. . . . Albano (near Rome).
Alman. . . Almomdola.
Alp. . . . Alpines (South France).
App. . . . Appenzell.
Aq. . . . Aquila (Abruzzo).
Arc. . . . Arezzo (Tuscany).
Arg. . . . Argenlik (Albania).
Arnh. . . . Arnsberg.
Asch. . . . Aschaffenburg.

B

B. . . . Bellinzona.
B. . . . Boja (Albania).
B. . . . Borgo (near Trient).
B. . . . Bushau (Bohemia).
Bab. . . . Babagum or Babia-Gura (Carpathians).
Bad. . . . Baden.
Ball. A. . Ballon d'Alsace (Vosges).
Ball. S. . . Ballon of Soles "
Banial. . . Banialuka (Bosnia).
Barcel. . . Barcelonnette (West Alps).
Bas. . . . Bassano (Upper Italy).
B. C. . . . Ben Cruachan.
Bensky Hd. . Beachy Head.
Bell. . . . Bellano (South Alps).
Ber. . . . Pass Bernina (Central Alps).
Bewes. . . . Bemmyes.
Bibr. . . . Bibrach.
B. L. . . . Ben Lomond.
Bl. . . . Blenberg.
B. Lawers . . Ben Lawers.
Bin. . . . Blomberg (Thüringer Wald).
B. Mor . . . Ben More.
B. M. D. . . Ben Mack Dui.
B. Nevis . . Ben Nevis.
Bo. . . . Botzer (Tyrol).
Bod. . . . Bodenburg.
Bog. . . . Bognakoe (Turkey).
Bohlsph. . . Bohler Hill.
Bourg. . . . Bourgea.
Br. . . . Brenley (Lorraine)
Brem. . . . Bremer Pass.
Bress. . . . Bressoire.
Brist. . . . Briancon.
Brsbk. . . . Brecken.
Budz. . . . Budweis.
Burg. . . . Burgkirk (Greece).
Bull B. . . Bull-Barrow.
Butt. . . . Buttenhausen.
Bz. . . . Brüx (Bohemia).
Bz. . . . Bautzen.

C

C. . . . Cascia, Civita di (Abruzzo).
C. . . . Cassel (Hessen).
C. . . . Castonia (Macedonia).
C. . . . Cerro di Canze (South Alps).
C. . . . Cruja (Albania).
Ca. . . . Castellveria (Abruzzo).
Cab. d. Maria Cabeza de Maria.
Cabirer. . . Cabirecoiree, or Cabirconrigh.
Calm. . . . Calmuck.
Can. . . . Canigou (Pyrenees).
Canal. . . . Plomb du Cantal.
Car. . . . Caren.
Carr. . . . Carrasenne.
Carlsrh. . . Carlsruhe.
Carrf. . . . Carterfell.
Cas. . . . Cassino.
Cast. . . . Castelnaudary.
C. D. . . . Civita Duralo (Abruzzo).
C. d'Ad. . . Cima d'Asda (South Alps).
C. d. F. . . Col de Fenêtres.
C. d. L. . . Canal de Languedoc.
C. d. P. . . Cima di Portola.
Cand. . . . Cerdon.
C. G. . . . Cairngorm.
Ch. . . . Chasseron (Helvetian Jura).
Ch. . . . Chesnet Peak (Carpathians).
Ch. . . . Chur (Grisons).
Chert. . . . Chartreuse, Great.
Ch. M. . . Chemin du Cheval Blanc.
Chi. . . . Chiavenna (South Alps).
Cist. . . . Cisterna.
Clar. . . . Clermont.
C. M. . . . Cerro Mallucca.
C. Mat. . . Cape Matapan.
Cob. . . . Coburg.
Cobl. . . . Coblenz.
Col. . . . Colmar.
Col-D. . . Col-Dorg.
Const. . . . Constantinople.
C. R. . . . Col. Rohereut.
Crf. . . . Crefeld.
Cuxs. . . . Cuxhaus, Monte.

D

D. . . . Dievdior (Carpathians).
D. . . . Dolmar (Thüringer Wald).
Darm. . . . Darmstadt.
D. Bral. . . Deutsch Brod (Bohemia).
D. d. M. . . Dent du Midi.
Dk. . . . Drahbreis (Central Alps).
Dl. . . . Dijon (France).
Dr. . . . Dyzmerka (Albania).
D. O. . . . Domo d'Ossola.
Dr . . . Dilli.
Dürn. . . . Dürnberg.
Dor. . . . Dorrenfeld.
Dres. . . . Dresden.
Dreyp. . . . Dreyssenflerg.
Dsmd. . . . Dürnenderf.

E

E. . . . Etropol.
Eg. . . . Egerenberg.
Ejri Pal. . . Ejri Palanka.
Elchf. . . . Elchefeld.
Ess. . . . Esserbet.
E. M. . . . Ethes Mountain (Greece).
Epi. . . . Epinal.
Erbs. . . . Erbsenkopf Wald.
Estella . . . Estella, Alta del (Cantabr. Mountains).
Eski S. . . Eski Sagra.
Espad. . . . Cerro de Espadas.
Ets. . . . Grands Etaids.
Etzw. . . . Ettenberg (near Weimar).

F

F. . . . Feltre (Venice).
F. . . . Florina (Macedonia).
F. . . . Frankenstein (on the Rhone).
F. . . . Friedberg (Bohemia).
F. A. . . . Finster-Aarhorn.
Fa. . . . Fatra.
Fa. . . . Fatra (Hungary).
Fay. . . . Les Fayons.
Feld. . . . Feldsin-Berg.
F. d'Otlo . . Fuest d'Otlo.
Fe. . . . Felizzano (Piedmont).
Feldb. . . . Feldberg (Schwarzwald).
Feldb. . . . Feldberg (Taunus).
Fleb. . . . Flattenberg (Erzgeb).
Flen. . . . Flonterenkau.
Flor. . . . Florelle, Monte.
Fo. . . . Foligno.
Folgf. . . . Folgefond.
For. . . . Formentera.
Fr. . . . Freiberg.
Frey. . . . Freyberg.
Freis. . . . Freiwalde.
Freg. . . . Freystadt.
Fu. . . . Fulda.
Fün. . . . Fünen.

G

G. . . . Gazza, Monte (South Alps).
G. . . . Gotha.
Ga. . . . Gallenstock.
Gab. . . . Galgenberg.
Gar. . . . Guarda.
G. B. . . . Gleichberg, Great.
Gb. . . . Goldapperg.
Geb. . . . Gebirge.
Gebrh. . . . Geiersberg.
G. G.A. . . Glacier d'Arbin (West Alps).
Gb.-Hn. . . Monte Gibel-Rosso.
Gie. . . . Giessen.
Glockner . . Glockner, Gross.
Gmd. . . . Gemund.
Gobnh. . . . Gobnberg.
Görl. . . . Görlitz.
Gtt. . . . Göttingen.
G. Pelv. . . Pelvoux, Great.
Gr. . . . Gries, or Grienhorn Pass (Central Alps).
Gr. . . . Gronau (Westphalia).
Grnsh. . . . Grossenhain.
Gsb. . . . Geisberg, or Gaisberg.
G. St B. . . Great St Bernard.
Guadarrama Puerto de Guadarrama.
Gut. . . . Gutenbrunnen.

H

H. . . . Halle (on the Saale).
H. . . . Hamm (Westphalia).
H. . . . Hedegisling (East Alps).
H. . . . Hohenstein (Prussia).
Hagb. . . . Hagelsberg.
Hallds. . . . Hallandsäs.
Hallng. . . . Hallingskarven.
Harzb. . . . Harzburgen.
Hasen. . . . Hasenmatte.
Hb. . . . Hasenberg (Prussia).
Hb. . . . Hardenberg (Netherlands)
Hdl. . . . Helilberg.
Henjo. . . . Henjehögen.
Hermannst. . . Hermannstadt.
H. G. . . . Hoho Göll.
Hhtsn. . . . Hohenstein.
Hb. . . . Hochkant.
Hlms. . . . Holzminden.
Hls. . . . Hörnll.
Hn. G. . . . Hohgant.
Hohh. . . . Hohenberg.
Hoh. E. . . Hohen-Elbe.
Hoors. . . . Hoorsäls.
Hoperw. . . Hoyerswerda.
Hrad. B. . . Hradawa Mountains.
Hsn. . . . Hannenfeld.
H. Vog. . . Hoskevgel.

I

Ib. . . . Ibas.
Ic. . . . Isenberg.
Ingd. . . . Ingolstadt.
Ingr. . . . Inkpen Beacon.
Insb. . . . Innsbruck.
Iornow. . . Iornowrud.
Isch. . . . Ischel.
Isert. K. . . Iserkamm.
Ist. . . . Istib.
Iv. . . . Ivina.

J

J. . . . Janina (Albania).
J. . . . Jungfrau (Central Alps).
Jabl. . . . Jablunka Pass.
Jav. . . . Javorin.
Jenk. . . . Jenkfeld.
Jesi S. . . Jesi Sagra.
Jn. B. . . . Jaschkenberg.
Jor. . . . Jorat.
Judb. . . . Judenberg.
Justed. . . . Justedal.

K

K. . . . Kallendorf (Albania).
K. . . . Kesoban (Thrace).
K. . . . Krakows-Hals (Carpathians).
K. Ast. . . Kable Aastenberg (Lower Rhine).
Katseh. . . Katschanik.
Katseh. . . Katzenbuckel.
Kb. . . . Karlsbad (Bohemia).
Kbe. . . . Kohnstberg (Bühmer Wald.)
Kbz. . . . Kongsberg.
Kcngn. . . . Kenigen.
Kcn. . . . Kennzilk.
Kcnrng. . . Kongsvinger (Glommen Mountains).
Kbd. . . . Kholenn.
Kl. . . . Klock.
Klnjenf. . . Klagenfurth.
Kltstt. . . . Klattau.
Knock M. D. Knock-Meal-Down.
Kcl. . . . Kejani.
Kcbb. . . . Kobelzbrunn.
Kcnigz. . . Königsgrätz.
Kcrsbg. . . Kerzberg, Great.
Kpla. . . . Kapella, Mount.
Krs. . . . Krems (Austria).
Krs. . . . Krimchow.
Krv. . . . Krivan (Tatra Group).
Krv. B. . . Krivsberg.

L

L. . . . Langres (France).
L. . . . Lanieu (Thessaly).
L. . . . Leontfelden (Bühmer Wald.)
L. . . . Liebkowitz (Bohemia).
L. . . . Lissnua (Abruzzo).
Lnd. . . . Landau.
Lndtl. . . . Landeskrone.
Lnf. . . . Lanfuhrn.
Lnjh. . . . Layhach.
L. Ch. . . . La Chartd.
L. d. Cds. . . Lago di Cedoso, or Facino.
L. d. Gi. . . Lago di Garda.
Ldd. . . . Lebdrow, Chaine de.
Lds. . . . Ildmuich Leipa.
Lelp. . . . Leipzig.
Lelt. . . . Leitmeritz.
Lenb. . . . Leuben.
Leubach. . . Leubachhütte.
L. F. . . . La Foya, culminating point of the Sierra Moschigon.
Lhtt. . . . Lichtenberg.
Lign. . . . Lignières.
Lnlcn. . . . Lilienfeld.
L. L. . . . Loch Lochy.
L. M. . . . Lago Maggiore.
L. M. . . . Lauenenser Hills.
L. N. . . . Loch Ness.
Lnlph. . . . Lobale Raabe.
Lnlh. . . . Leibel.
Lom. . . . Lomnitz Peak (Tatra Groupe).
Lnsby. . . . Luxemburg.
Lwh. . . . Lowther Hills.

M

M. . . . Mezen (France).
M. . . . Magdeburg.
M. . . . Malgara (Thrasia).
M. . . . Marmuser See (Prussia).
M. . . . Col de Manchecon (Jura).
M. . . . Malea.
M. . . . Melenik (Macedonia).
M. . . . Mesnil la Horgne (Lecharnigla).
M. . . . Milizwo (Albania).
M. . . . Mollayon, Cerro de (S. Nevada).
M. . . . Münster (Valtlin).
Macell. B. . . Magillimsky's Berks (summit Cam Tual).
Mal. . . . Maladetta * (Pyrenees).
Man. . . . Manchester.
Mar. . . . Marlow (Merklenberg).
Mar. . . . Marmolata (South Alps).
Mer. . . . Marseilles.
Mirnhd. . . . Märenkafeld.
Margor. . . . Margaride.
Matagall. . . Matagallos.
Mb. . . . Marienberg.
M. B. . . . Mont Bouseer (South Alps).
M. B. . . . Monte Brasone (South Alps).
Mby. . . . Marienberg (Saxony).
Mby. . . . Müggelsberg (near Berlin).
M. C. . . . Mont Cinto Christo (near Corsica).
M. C. . . . Moni Carsura (Central Alps).
M. C. . . . Monte Cavo (near Rome).
M. C. . . . Mont Canis (West Alps).
M. C. . . . Mont Colombier (Helvetian Jura).
M. Capon. . . Mont Capanne.
M. Cl. . . . Monte Clusone.
M. D. . . . Mont Dauphin.
M. d. Arca. . . Mtuela de Arca.
M. d. Charol. . . Montagnes du Charolais.
M. d. Estre. . . Montagnes d'Estrella.
M. d. L. . . . Montagnes de Lure (South Alps).
M. d. L. C. . . Montagnes de la Cazne.
M. d. M. . . . Montagnes des Maures.
M. d. Morph. . . Montagnes de Marghine.
M. d. Mor. . . Montagnes de Morvan.
M. d. Tier. . . Mola di Taormina.
Med. . . . Mediasch.
Mednz. . . . Medvenic.
Mein. . . . Meinsner.
Memm. . . . Memmingen.
Mendip. . . . Mendip Hills.
M. Fich. . . . Mont Fichorieu.
M. fleur. . . . Meuilleurtvouny.
M. G. . . . Monte Ganio, or Gavio (near the Ortler).
M. G. . . . Monte Gargano (on Lago-di Garda).
M. Gth. . . . Moni St Gothard.
M. Gv. . . . Mont Grenier.
Min. . . . Minden.
Mlls. . . . Milsen Lake.
Mlttsh. . . . Miltenberg.
Mtz. . . . Mitterlitza.
Mtzg. . . . Mittelgebirge.
M. Jos. . . . Mont Javoult.
M. Jur. . . . Mont Jargeau.
Ml. . . . Meleda Island.
M. Leg. . . . Monte Legnone (South Alps).
M. L. . . . Mont Louis (Pyrenees).
Mlbh. . . . Melibokus.
M. M. . . . Mount Maleva.
M. M. . . . Minena Magl.
M. Mag. . . . Monte Maggiore.
M. Mau. . . . Mauro, Monte St.
Mel. . . . Melsonen.
Mon. . . . Montabauer.
Montp. . . . Montpellier.
Mn. . . . Montagne de Mouset, or Mousset.
Mst. . . . Mostar (Herzegowina).
Mnrch. . . . Monchefeld.
Mnst. . . . Munster.
Mp. . . . Meppen.
M. Pk. . . . Monte Pietch.
M. Sc. . . . Monte Scopo.
M. Soriza. . . Monte Soriano.
M. St Ang. . . Monte San Angelo.
M. T. . . . Monte Terrible.
M. Tor. . . . Moni Toro (Minerva).
Mnich. . . . München.
Mayn. . . . Magnanfeld.
M. V. . . . Monte Vendia.
M. Ven. . . . Monte Ventoux.

N

N. . . . Nevesign (Herzegowina).
N. . . . Narcia (Abruzzo).
Nbld. . . . Neidenburg.
Nov. Pl. . . Novezzia Planina Mountain.
Nb. . . . Nellenhaus.
Nord. . . . Nordhausen.
Nrd. . . . Nördlingen.
Nvn. . . . Nevinnan.
Nrnb. . . . Nürnberg.

O

O. . . . Oro, Monte dell'.
Ob. . . . Oberahorf (Schwarzwald).
Ob. . . . Otlen, or Obiona (South Alps).
Obhf. . . . Orbenkopf.
Obnw. . . . Odenwald.
O. Fa. . . . Orthaler (Farther).
Olb. . . . Olberg.
On P. . . . On Planina.
Or. . . . Ormlenberg.
Os. . . . Osseru, Monte.
Osmn B. . . Osman Bazar.
Osnb. . . . Osnabrück.
Osni. . . . Ossmiana, Heights of.

P

P. . . . Padua.
P. . . . Peisenberg (near Halle).
P. . . . Prespa (Maced., East of Lake Ochri).
P. . . . Prilip (Macedonia).
P. . . . Prevan (Albania).
Pod. . . . Podorbora (Westphalia).
Pod. . . . Padolia.
Pop. . . . Papreber Berg.
P. R. . . . Peissenberg.
P. H. . . . Pentland Hills.
Pldm. . . . Potsdam.
P. d. Catanis Piana di Catanis.
P. d. E. . . . Pirrou des Encombres.
P. d. F. . . . Pic de Fourgout.
P. d. Guadarra Puerto de Guadarama.
P. d. M. . . . Puerto de Mouatseria.
P. d. M. . . . Pay de Montcrelie.
P. d. Pist. . . Puerto de la Pista.
P. d. Rey. . . Puerto del Rey.
Pell. . . . M. Pellegrino (Sicily).
Penn. . . . Pennsen Mawr.
Pompf. . . . Pompeiana.
Per. . . . Perimglia.
Petern. . . . Peterswalden.
Pfal. . . . Philippsfeld.
Piano d. C. M. Piano di Cheque Miglia.
Pirn. . . . Pirnasenz.
Plaak. Gb. . . Planchkaritza Mountain.
Plo. . . . Plochingen.
Plock. . . . Plockenstein.
Pd. M. d. B. . . Pic du Midi de Bigorre.
Pd. M. d. P. . . Pic du Midi de Pau.
Pod. . . . Podgwitza.
Pol. . . . Poland.
Po. . . . Pokrut.
Pollp. . . . Pollingy.
Pon. . . . Ponte.
Pots. . . . Potsberg.
P. P. . . . Pic Pontis.
P. s. Calm . . Puy se Calm.
P. s Hants . . Pierre sur Haute.
P. V. . . . Pic Viell.
P. W. . . . Furia Westphalica.

Q

Quef. . . . Quedlinburg.
Qusch. . . . Quethiock Hill.

R

R. . . . Radkersburr Tannen (East Alps).
R. . . . Raisick (on Doguito Dagh).
R. . . . Ravensberg (near Potsdam).
R. . . . Retulet (Jura).
R. . . . Rista (Middle Apennines).
R. . . . Rotola.
Radica. . . . Radicofani.
Ramg. . . . Ramsgillon.
Rmb. . . . Rathhausberg.
Rn. . . . Rinemberg.
Rb. . . . Romberg.
Rbtz. . . . Rehnera.
Rn. . . . Rochen-Schlobeck.
Rgnsbg. . . Regensburg (Ratisbon).
Rio. Cova. . . Rocra Cuva.
Rmb. . . . Rocca Melone, or Roche Melon.
Rmnd. . . . Rimmini.
Rosc. . . . Roncas Valles, or Roncevaux.
Rück. . . . Rückenberg.
Rmd. . . . Rundene (Rundafjeld Fichhätten).
Rst. . . . Rotefjeld.

S

S. . . . Saaz (Bohemia).
S. . . . Seres (Macedonia).
S. . . . Spliigen (Central Alps).
Saarby. . . . Salzburg.
S. Alban. . . Sierra de Alhama.
S. Arabid. . . Sierra d'Arrabida (culminating point of the Formosinho).
Sal. . . . Salfeld.
Sal. . . . Salona.
Salina . . . Salina (Sierra de).
Sall. . . . Sallanche.
Sap. . . . Sapada, or Supada.
Salzb. . . . Salzburg.
Sb. . . . Schönningerberg.
Sc. . . . Scutari.
Sch. . . . Schalia (Albania).
Schenn. M. . . Schemnitz Mountain.
Sch. . . . Monte Schiena d'Asino (near Rome).
Sch. . . . Schio, City (near Verona).
Sch. . . . Schneekopf (Thüringer Wald).
Sch. . . . Schwerin (Mecklenburg).
Schcf. . . . Schafhausen.
Schenn. . . . Schaumburg.
Schb. . . . Schneeberg, Town.
Schl. . . . Schlala.
Schrb. . . . Schlern, Berg.
Schn. . . . Schneeberg (East Alps).
Schn. . . . Schneeberg (Sudetic Mountains).
Schneeb. . . Schneekoppe.
Sesch. . . . St Dié, or St Diey.
Shekall. . . Shehallion, or Shehallien.
Serr. . . . Serre.
Sep. . . . Sepada.
Sez. . . . Sezza.
Sibenjh. . . Siebengebirge (seven Mountains).
Sieg. . . . Siegen.
Sigm. . . . Sigmaringen.
Sim. . . . Simplon.
Skagfil. . . Skagerfiddad.
Skr. . . . Skarvon.
Skardfl. . . Skardalsporten (road near Lake Skrudal).
Sm. . . . Semmelberg.
S. M. . . . St Marie aux Mines.
Smnh. . . . Schneeberg (near Triest).
Snnh. . . . Schneeberg (near Vienna).
Solst. . . . Solstein.
Soep. . . . Soepa.
Sp. . . . Spoleto.
S. R. . . . See Rikavetz (Lake Rikavitz).
S. Alba. . . Sierras Albas (Cantab. Mountains).
Sr. d. Guara . . Sierra de Guara.
S. Sal. . . . San Salvador.
St. . . . Hohe Sentis.
St. . . . Sterzing (Tyrol).
St. . . . Strela, or Türkli Schoidock (Grisons).
St. Alp. . . Stang-Alp.
St. B. . . . St Bernard (Little).
St. Ben. . . St Benedik.
Starch. . . . Starrabergerberg.
St G. . . . St Genis, or St Genix.
St Hy. . . . St Hyppolit.
St Is. . . . St Ildefonso.
St Is. . . . St Isoire.
St J. . . . St Johann.
S. Tpl. . . . Sierra Tripla.
St Jean P. d. P. St Jean Pied de Port.
St Mart. . . St Marcello.
St M. d. Ch. . . St Martin de Chantien.
St Max. . . St Maximin.
St Mh. . . . St Mendhould.
Star. R. . . Starellen.
Str. . . . Stradowed.
St L. . . . St Lovelin.
St ren. . . . St Stephan.
St Stef. . . . St Stefano.
Stutt. . . . Stuttgard.
St V. . . . St Victoire Mountain.
Such. . . . Suchet Mountain.
Sal. . . . Salmona.
Sychar. . . . Sychar'ca.
Sylt. . . . Sylifield, or Sylikop.
Sz. . . . Szawi.

T

T. . . . Tagliaferro (Central Alps).
T. . . . Teschen (Bohemia).
T. . . . Tonnisnee (Bretagne).
T. . . . Tricala (Thessaly).
T. . . . Trajak (Macedonia).
Tesh. . . . Teshen.
Tog. . . . Tagliacosmo.
Tom. . . . Tamerwig.
Torne . . . Tarnow.
T. Druj. . . Telenka Druja.
Tel. . . . Telnitz.
Temp. . . . Tempfin.
Tm. . . . Hohe Tennergebirge.
Tend. . . . Mont Tendre.
Terol. . . . Termiglia, Grands ed Piccla.
Thürnh. W. . Trötteburger Wald.
Th. . . . Thorndorf.
Tk. . . . Tirli.
Tobl. . . . Tobiach.
Tomor. . . . Tomoros.
Torp. . . . Torpan.
Torisene. . . Sierra de Torinanna.
Tr. . . . Mont Trelot (West Alps).
Tr. . . . Trent.
Tr. . . . Trier.
Tripol. . . . Tripolitza.
Troufl. . . . Troufield.
Trsk. . . . Tellaniiza.
Tatsin. . . . Transsbein.

U

Ullmar. . . . Ullenwang.
Uzb. . . . Uzkiah.

V

V. . . . Valeria, Pic (Sierra Nevada).
V. . . . Grand Ventron (Vosges).
V. . . . Viterza (Upper Italy).
V. . . . Vigo (Tyrol).
V. . . . Vogel (Source of Rhine).
Vdd. . . . Mitterwaldau (in the Vale of Valdres).
Velp. . . . Valplan.
Vetz. . . . Vattendalsfjeld, Pass of.
V. d. D. . . . Val de Dien.
Vd. . . . Velutzki (Greece).
Vena. . . . Venasque.
Verd. . . . Verdun.
V.-franca . . Villa-Franca.
Vg. . . . Vignemale (Pyrenees).
Vgk. . . . Vignefjeld (Vigelus Peak).
Vill. . . . Villach (East Alps).
Vill. . . . Villingen (Schwarzwald).
Vrn. . . . Voirons.
Vrun. . . . Vranata.

W

W. . . . Wildberg.
Wann. . . . Warmoen.
Wm. . . . Weimar.
Wstone. . . . Westerwald.
Wlds. . . . Wildonhof.
Wz. . . . Wittenberg.
W. R. . . . Wermser Ridge.
Ws. . . . Wesel.
Wd. . . . Wendy.
Wrzbg. . . . Würzburg.

Y

Yer. . . . Yverdon.

Z

Z. . . . Zürich.
Zells S. . . Zirknitzer See.
Z. M. . . . Zeda Monte.
Zw. . . . Zwettel.

* The highest valley in the Apennines, 6703 feet High.—Schouw.
† On Malmiton (Mont Rundle) to Pic Sechon or Anethon, the culminating point of the Pyrenees.

NOTES ON

SOME GENERAL PRINCIPLES IN GEOLOGY;

AND THEIR APPLICATIONS.

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A.

EXPLANATIONS RELATING TO THE CONSTRUCTION OF M. BOUÉ'S GEOLOGICAL MAP OF THE GLOBE.

(CHIEFLY ABSTRACTED FROM M. BOUÉ'S MEMOIR IN THE "BULLETIN DE LA SOCIETE GEOLOGIQUE DE FRANCE." Tom. Premier, Deuxieme Serie.)

The work which—as revised afresh by M. Boué—is now presented to the student of the Physical Atlas, is one of those efforts, which only an Inquirer, combining extensive and accurate knowledge with singular powers of generalizing, can be entitled to undertake: and as it is altogether novel, as well as peculiar in character, it will be necessary to append to it a longer explanatory statement than has been required in our previous Numbers, so that its pretensions, authority, and import, may be rightly understood.

I.

Considering the greatness of his enterprise, and the imperfection of our knowledge of the details of the geological structure of the globe, Boué very wisely restricted himself to an attempt to trace the distribution and arrangement of six grand formations or groups of rocks; including, of course, in each formation, a long series of products and changes, connected by artificial, if not natural relations. The six groups, are these :—

I. THE CRYSTALLINE SCHISTOUS FORMATION, COMPREHENDING ALL THE GRANITOID ROCKS.

II. THE PRIMARY STRATIFICATIONS, OR THE TRANSITION SERIES, INCLUDING THE CARBONIFEROUS FORMATION.

III. THE SECONDARY FORMATION, EXTENDING FROM THE CLOSE OF THE CARBONIFEROUS SERIES TO THE CLOSE OF THE CRETACEOUS.

IV. THE TERTIARY FORMATION.

V. THE ALLUVIUM, OR MODERN DETRITUS.

VI. VOLCANOES: IGNEOUS ROCKS OF THE TERTIARY AND ALLUVIAL EPOCHS; AND SOME EXTRA-EUROPEAN PORPHYRIES AND DIORITES.

The colours indicating these different groups are explained on the map.

II.

In the essay accompanying his work, as well as in the "*Guide du Geologue Voyageur*," Boué has given a list of his authorities in respect of the distribution of these six groups; and it is doing him only justice, to say, that his list forms, at the present moment, our most complete bibliography of geological literature. But however ample these positive materials, they are yet far from sufficient to entitle any one to construct, by the mere arrangement of separate established facts, a geological map of the globe. Let every district, hitherto actually examined, be coloured on a map of the world,—and, assuredly, the surfaces thus distinguished would appear very unimportant in magnitude compared with the others, exhibiting the absence of all knowledge derived from personal and approved inspection. Fortunately, however, the parts of the globe, whose constitution has been laid bare by actual scrutiny, manifest unequivocal marks of the prevalence of order and system in the arrangement of the various formations; and although the relations thus indicated are not yet in all respects perfectly defined, nor the irregularities or apparently exceptional cases connected with them sufficiently known, they still justify us in drawing inferences from single facts, that are often *highly probable*. A map constructed, in a great measure, in reliance on laws and relations which are not absolutely established, cannot indeed pretend to minute accuracy: but instead of being therefore disregarded as the result of an ambitious fancy, or a mass of mere barren conjecture, it must—in so far as it conscientiously presents the sum of our positive knowledge, and rests its deductions only on the most general of the laws hitherto recognised—be received as one of those important and vigorous *reconnoissances* which are often the useful preludes and pioneers of solid discovery.

The facts from which the geological structure of an unexplored country may, with any degree of probability, be deduced, are manifestly those of Physical Geography. This branch of knowledge is merely a description of the forms into which great Revolutions have cast the present surface of the earth; and as these forms must be supposed to indicate the nature of their producing causes, similarity in the contour of distant portions of the earth's surface should thus, in so far, indicate similarity in geognostical constitution. The expected analogy, indeed, often prevails even with regard to extremely minute features. Comparing, for instance, the central spine of Asia, from the Taurus and Caucasus to the Pacific, with the Alpine masses of Europe, it is not difficult to perceive a most striking correspondence among all their dependencies. In each of the two continents lying between enormous hollows now filled by seas, we find a large central mass or nucleus, composed of schistous and granitic rocks, bifurcated at its extremities, where it exhibits transition and secondary formations, also found to the north. If Asia Minor, in so far corresponds with the Pyrenees and the ancient and partly igneous isle of central France, the Hungarian and Styrian basins between the divisions of the Alps, are repeated in China on a very large scale; whilst the basin of the lower Danube corresponds with that of Touquin, and other districts of Turkey in Europe are virtually reproduced in the peninsula beyond the Ganges. On the shoulders of the Central Asiatic mass we find the same secondary chains as in the Alps; and, in both continents, tertiary deposits fill up isolated basins among the mountains, in the form of low heights, between the secondary zone and the tertiary and alluvial plain. Regarded from the same point of view, the deserts of Turkestan and Mongolia are only a repetition of the great tertiary and alluvial valley to the north of the Alps; the immense valleys of the Ganges and lower Indus recall those of Piedmont and Venetian Lombardy; whilst the basins of the higher Euphrates, of Cabool, Cashmere, Ladak, Lassa, &c., have counterparts in the isolated tertiary cavities of Belluno, Carinthia, of the upper Mulr, the upper Inn, &c. Nor does the likeness stop even here; for if the calcareous Alps of Asia enclose isolated tertiary basins like those of Europe, they exhibit also, in places precisely similar, clefts or passages opened by nature which have in both instances been the arteries of commerce, and the defiles whose possession has always ranked so important in war; and in localities exactly corresponding, we have the seats of civilization and power. It is scarce needful to refer to the enclosed basins of Persia, Tibet, Cashmere, &c.; the *cols* of the Hindoo Koosh offer similitudes to the well-known *cols* of the Swiss Alps:—"Delhi," says Boué, "is Milan, Calcutta reminds us of Venice, while Bombay is the counterpart of Genoa."—Passing from the great central masses themselves to their environs, we are likewise everywhere met by close and unlooked-for analogies. North of the Asiatic protuberance beyond the cavity of the desert, the Altai presents a crystalline and transition region resembling what is found in Europe north of the tertiary depression bordering the Alps; and in Asia, as in our own more neighbouring region, secondary and alluvial deposits divide the districts now referred to, from the older formations which constitute the northerly portion of both continents. So also in the south, Spain seems the analogon of Arabia; Corsica, Sardinia and Italy, of Hindostan; and Greece and Turkey, of the peninsula beyond the Ganges. That these resemblances are not fanciful, a glance at the map will readily manifest; nay, with due allowance for the effect of local and particular accidents, the analogy might be traced much farther—to the identification, for instance, of the chain Soliman—the prolongation of the Bolor—with the Maritime Alps; and even to the position of the immense hollows which, in both continents, are filled with water. Descending to still smaller minutiæ, it is not easy to escape being struck by the singularly corresponding distribution of the more strictly igneous or volcanic rocks. Is not the great basaltic district of Hindostan, for instance, a manifest counterpart of the extensive eruptions of serpentine and trachyte in Italy and Turkey; while the volcanoes and their deposits in the Mediterranean and its Archipelago, and those of Hungary and Asia Minor, have similitudes in Cutch, the Sunda Isles, the Malayan Archipelago, Japan, and Kamtchatka? North of the Alps we find only a few knolls or domes of igneous rocks of this family; now this accident seems exactly repeated in Asia in the lakes of borate of soda (*e.g.*, that of Tinkal in Tibet): while, at a greater distance from the central chains, the ancient volcanic districts of the Eifel, the banks of the Rhine, the north-west of Germany, and northern Bohemia, seem represented by elevated groups, such as the Caucasus, Ararat, and Demavend, the trachytes between the Caspian and Lake Aral, and the volcanic zone around Lake Baikal.

This remarkable conformity of feature through two immense regions—a conformity as striking as the dissimilarity between the structure of either continent and the physical geography and geology of Africa and America—seems to establish, or at least to endow with a singular probability, what has been laid down as the fundamental idea of speculative geology, viz., that a critical similarity of outward form, while indicating similarity in the producing causes, must also, to a large extent, indicate identity of structure: but this conception by itself, being too general to further an enterprise so definite and determinate as M. Boué's, he has deemed it necessary to enumerate specifically all those separate external features, from which specific and substantive inferences as to the geognosy of a district may with comparative security be made; and his sagacity and rare ingenuity appear to have enabled him to collect, methodize, and estimate the whole important considerations, which, in the present state of our knowledge, can yield the remotest hint regarding the structure of an unexplored region. The results arrived at are presented with slight modifications as to arrangement, but considerably abbreviated, in the next section.

EXPLANATION OF THE COLOURS

1. The Crystalline schistous formation, comprehending all the Granitoid Rocks.
2. The Primary stratifications or the Transition series including the Carboniferous formation.
3. The Secondary formation extending from the close of the Carboniferous series to the close of the Cretaceous.
4. The Tertiary formation.
5. The Alluvium or modern Detritus.
6. Volcanoes, Igneous Rocks of the Tertiary & Alluvial epochs, and some extra-European Porphyries & Diorites.

Longitude W. of Greenwich

Longitude E. of Greenwich

THE GEOLOGICAL STRUCTURE OF THE GLOBE

ACCORDING TO AMI BOUÉ.

From the Large Chart Presented to the Réunion at Gratz 22nd Sept.r 1844

BY A. K. JOHNSTON, F.R.G.S.

with Dr Boués Corrections & additions to Sept.r 1846

ELIE DE BEAUMONT'S CHART OF THE ELEVATION OF MOUNTAINS

II System of the Bocage Hills — IV Netherlands System — V Rhenish System — VI S. of the Morvan Thüringerwald &c. — VII S. of the Erzgeb.e Plias. Cote d'Or

IX S. of the Pyrenees & Appennines — X S. of Corsica & Sardinia — XI S. of the Western Alps — XII S. of the Principal chain of the Alps

Andes

Explanation of Colours

1. Primary formation
2. Transition formation
3. Coal formation
4. Yeager Sandstone
5. Permian Sandstein, Muschelkalk, Keuper
6. Jura Chalk
7. Greensand and Chalk
8. Lower Tertiary formation
9. Upper Tertiary formation
10. Ancient Alluvial land
11. Recent Alluvial land

Numbers 1 & 2, shown in the Map by different degrees of shading, are here coloured Pink and Blue respectively.

SUPPOSED ANTARTIC CONTINENT

ILLUSTRATIONS of the SYNCHRONISM of PARALLEL CHAINS

THE PRINCIPAL MOUNTAINS OF THE GLOBE ARRANGED ACCORDING TO GEOGRAPHICAL LONGITUDE, WITH ELEVATIONS ABOVE THE LEVEL OF THE SEA.

Height in Feet — Kingdom — Latitude — Level of the Sea

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A. K. Johnston

craters, having sometimes an outlet, as the Lake Pavin in Auvergne. Thus, if some small lakes in the steppes of the Kirghis are probably analogous to the lakes of depression (sinking) of Elabon or Pyrmont; the trachytic lakes of Laach, of Bolsena, St Anne in Transylvania, of Gonbar in Abyssinia, of Genkeho, of Urumiah in Asia, and of Nicaragua in America, are manifestly ancient volcanic cavities, somewhat increased by *ecroulements*. This description of hollows may have been formed amid the granitic, siemitic, porphyritic, and serpentine eruptions, as well as amid the trachytes; but their preservation amid those older rocks is much rarer—they are there more or less broken, which much reduces the number that can now be recognised. As instances, may be cited a small granitic lake surrounded by precipices in Csirnopurn; and probably another in Tatra in Hungary. In the siemitic formation, we have the Lake Corsiak in Skye; in the protogine, that of Kastoria in Turkey, filled in part with tertiary deposits; in Central Asia, the lake of Alakta-kul, with its porphyritic island, and that of Janisko, are perhaps other examples.

b. Lakes in the crystalline schistous formation have usually a very elongated form; they are surrounded with narrow bays, have inclinations more or less steep, and sometimes contain islands. These lakes are, in fact, masses of water filling the longitudinal or transverse clefts in the crystalline schists, and their shape is that of these clefts. They are still found, with all their characteristics, among the three great crystalline formations of the north of Europe, viz., in Scotland, Scandinavia, and Finland; but the numbers that previously existed in the same soil in other parts of this continent, have left only their destitute, as those of Pongam in the Tyrol, and Salzburg.

c. The lakes of the transition series are characterised by an oblong form; an undulating contour; very gentle inclinations of their shores; the midst of them rising little elevated, or even flat; and also by their neighbourhood to hilly regions, and the crystalline schists. They are so abundant in the globe, that an entire chain of them may be traced round the whole Northern Hemisphere. A glance at the map shows that all the lakes which traverse North America are in this formation, and that their direction is very constant, from north-west to south-east along the two slopes of the crystalline chain which, with the Rocky Mountains, forms the chief mass of the northern continent. The same thing occurs in Europe and Asia; in the one continent, a zone of lakes extends from south-west to north-east across Northern Russia; and in the other, with a parallel direction, a zone extends from the shores of Aral, as far as Lake Baikal: so also, we find a chain among the countries between the Lena and Kolyma. It is probable that the destruction of much of the transition series has greatly altered the contours of the Baltic, the White Sea, the Caspian, the Black Sea, and even of the Mediterranean; for their banks often exhibit crystalline rocks, and have also only the steep, undisturbed rocks that may once have covered them. The forms of those seas recall, besides, the shapes of the great lakes of North America, the figure of the Baltic resembling that of the Slave Lake, while Hudson Bay is not unlike the Black Sea, &c. Now, if it is proved that the American lakes have chiefly originated in accidents occurring within the transition series, may it not be concluded that these seas had a similar origin? It is evident, from a survey of the entire globe, that the earlier strata, especially the calcareous ones, are more favourable than any others to the formation of great cavities or depressions, whether these have been occasioned by fallings in, or denudations, or the explosion and escape of gases. The frequent horizontality of those ancient masses, the neighbourhood of the crystalline schists, as well as the upheavals and other changes undergone by the latter, have probably much influenced an occurrence so general.

d. The lakes, often very deep, in jurassic and cretaceous districts, have characters altogether peculiar; some occupying the bottom of cavities that have fallen in, very much resemble craters, as the Lake of *Issoire*, or of Pavin in Turkey in Europe. The Neapolitan peninsula contains numbers of this description, as in the neighbourhood of the Phlegrean Fields, &c., which, unless that the cliffs around them are secondary rocks, one would fail to distinguish from the openings of old volcanoes: instances are, the lake east of Nocco, and that south of Cima Nuova. Others in the same formation are really plateaus engulfing rivers,—situated generally on the edge of cliffs, but also at the bottom of valleys. In the former case, the intermittent ponds have no outlets sufficiently capacious for all the waters received; which accumulate at the surface and form lakes whose size varies with the seasons. Of this kind are Lake Topolias in Greece, the Lakes of Carniola, of Dalmatia, &c. Rivers disappearing and re-appearing in some places accompany such lakes; in the cretaceous formations especially, it appears that the streams engulfed and re-appearing are disgorged in the midst of a fluviatile bed, perfect as any other, but having part of its line quite dry, unless in very rainy weather. Examples are found in the course of the Kizil Irmak in Asia Minor, and in that of a tributary of the Narenta, between Gacko and Nevesigne in Herzegovina. A third species peculiar to recent secondary calcareous soil, is found in great lakes filling deep cavities in the calcareous mountains of the Alps and other chains, as, for instance, in China; or at their meeting with the tertiary basins, as in the case of the celebrated lakes in Lombardy. All these, formed by the elevating or destruction of the calcareous rocks, are distinguished from such as arise from *accroissements* of the contiguous secondary or tertiary formation, by the fact that they are surrounded by steep cliffs, or enclosed in shut up basins, whilst lakes of the other kind are found only in plains, or amid an undulating country, without any engirding crest.

e. Lastly, the *lakes of the plains* are merely cavities of very slight depth, where the water is kept in by dykes, or merely by alluvions and sandy downs; in the latter case, they are species of *lagunes* of more or less permanence. Exceptions are probably caused by clefts or subsidences of a subjacent formation.

III.—Intimations of geological structure derived from the phenomena of Deserts.

Among the facts of physical geography of greatest importance towards deciphering the geology of a country, we must rank the locality of DESERTS, or of places where water is rare, and vegetation almost or wholly wanting. Deserts, properly so called, infallibly point out districts of the globe into which, at a comparatively recent geological epoch, our present seas were prolonged in great gulfs or straits; or which were occupied by inland *mediterranean* that have now disappeared wholly or in part, and which gradually changed into fresh-water lakes previous to their escape or entire drying up. It is, in fact, a physical impossibility that a true desert can expose any *ancient* formation; for every district of that description must sooner or later have been covered by a more modern deposit, as soon as it began producing vegetation. It is rather in our present seas, or in their beaches are the only formations now in progress at all identical with deserts; and that it is only the tertiary formation, whether of salt or fresh water, and especially the arenaceo-cretaceous system which, by means of the variety of their soils, can originate expanses of sand *interspersed with fertile oases*. These facts serve to demonstrate the modern origin of deserts in general, and for, also, the comparative age of the red and white sandstones of Northern Africa. We *deduce*, further, that the formation of a desert presupposes the neighbourhood of certain soils, the presence of certain marine currents, and especially a position between great ancient chains of mountains which the water could abrade, in order to form with the sand a homogeneous portion of their structure, extensive enough to supply those conditions that we find in Egypt, in Nubia, in Dongola, towards the south of Sahara, in the regency of Tripoli, in Arabia Petræa, and Arabia Felix, and in Persia, the inferior cretaceous formation giving rise to moving sands and to rocks of friable sandstone, like those seen at Maua and in Saxon Switzerland; whilst in the rest of Sahara and of Persia, in Egypt, in Mesopotamia, on the banks of the lower Indus, in Central Asia, and Western Australia, the tertiary strata, or even the alluvions, have the chief share in the production of oceans of sand interspersed here and there with saline efflorescences.

IV.—Deductions from the mineralogical and palæontological characters of a Country.

These characteristics are very determinate indications of the nature of the formations of a country; whether we find them unwoven in its mythology, as in the case of the ammonites at the source of the Ganges, and the fossils in the Oasis of Jupiter Ammon; or specified as isolated curiosities by travellers. In fact, each *mineral kind* a special and distinctive position among the series of rocks; and every great group of formations is so distinctly characterised by peculiar *fossils*, that intimations regarding either—far more, regarding both conjoined—may be taken as a positive and certain index.

a. The topography of individual MINERALS, united to a study of their natural positions, acquires, from this notion, a most important importance of which few travellers have yet seemed aware; for even single lists of the metals of a country, or of its exchangeable products, enable us often to raise the veil that covers its unexplored geology. It is known that certain metals are as closely characteristic of certain formations as their peculiar fossils—witness the extremely limited geological relations of platinum, chromium, titanium, platinoid gold, &c. And in this way also the composition of the alluvium of larger rivers, frequently described by travellers, may become a tolerably expressive indication of the formations constituting the neighbouring mountain chains.

b. It is unnecessary to refer to the use the geologist may make of collections or even of single specimens of FOSSILS. It is enough to recall the conclusions that Von Buch was enabled to draw from the examination of some fossil shells of America, and those which are intimated by the presence of certain crustacea on the coast of Malabar, Tranquebar, Coromandel, China, Japan, Java, the Philippines, Borneo, and other islands in the Malay Sea. If the *Cancer maiæ verhelsus* of China, and the *Portunus trituberculatus* of Manilla, depote the existence in those countries of a recent tertiary calcareous formation, such probably as that of Java; the *Gonyopsis dalanus*, the *Gonyopsis tuerius*, and *emerythrata* are fossils of the tertiary clays of the *Sub Apennine* epoch in Hindostan and the Sea of Malacca.

c. The subject of ERRATIC BLOCKS may be noticed under this head: for although these come generally from a distance, they are pregnant with information. Thus the fact remarked by all travellers, that such blocks are scattered over North America in a line from north-west to south-east, from Mackenzie River to the Alleghanies and the Hudson, is sufficient ground with the geologist who has studied the European formations, for the presumption that, in the neighbourhood of this train of debris, there are very high mountains; and that to the east of the Rocky Mountains there must be a vast hollow along which these blocks were rolled or floated. In fact, a low land or zone from north-west to south-east, is found between the Rocky Mountains, and another schistous chain to the west of Hudson Bay: and all American geologists agree that the blocks have come down in those directions. But the nature of these erratic blocks gives an index of the constitution of the mountains from which they were originally broken off. Other blocks, not transported, but derived from the *decomposition* of rocks, yield likewise their instruction. Thus the masses of native copper, found here and there near the great lakes of North America, reveal the presence of traps and serpentines which have been in part destroyed.

d. Information regarding a few SEPARATE FORMATIONS in a district, is often of signal importance towards unfolding the leading features of its complete geology; because we interpret these by the analogy of the structure of known basins; and the importance of this key increases in proportion as the basins to be studied are large in extent, and the strata, therefore, more fully developed. Thus in China, as soon as we have learned from travellers and mineralogical specimens, that the great united basin of the Blue and Yellow Rivers is surrounded by chains of crystalline schists and granitoid rocks, we might be inclined to expect it occupied by the other more recent formations. But in regard to a portion of the Chinese shores, this supposition seems contradicted by the fact, that at the south of the Blue River a considerable portion of the maritime country is formed of these very crystalline schists and granitoid rocks—a branch from the central chain of the Asiatic Alps; whilst an ancient schistous formation constitutes also the promontory separating the Yellow Sea from the Gulf of Pe-chi-li. On the other hand, excellent coal, employed in certain provinces of China, indicates extensive transition deposits to the north-east of this empire, and to the south-east and near Nankin; and, lastly, it is easy to recognise the secondary formations by certain minerals coming from the south; whilst others prove that tertiary formations abound through the flat countries. We thus meet with the series of formations known in Europe; but these do not appear to be arranged in one cavity, but in two, viz., that of the Yellow and that of the Blue River—divided by a ridge of ancient crests. Resting, then, on these isolated data, is it not probable, according to the analogy of the formations of Europe, that these bands of deposits turn around the two basins referred to, and that the secondary Chinese soil stretches towards the north, to join that which forms the Asiatic Continent, opposite the Japanese Archipelago, as well as the western coast of Kamtschatka? If this is true, as probably we shall soon learn, we shall thus have arrived, *a priori*, at the final result of a great number of observations in detail, which, without affecting our views of the general position of these soils, will ultimately instruct us respecting their secondary peculiarities.—In the same manner, the tertiary soils in Asia, as yet so little known, may be disentangled. We find there two great secondary basins—that of the Obi and Irtish, and of the Lena, separated by a broad ridge of crystalline schists, which is bounded by the transition rocks that form the northernmost promontories of Siberia; to the west of the Obi as far as the Ural Mountains, and to the east of the Lena, a mountainous triangle of transition beds. To the south lies a series of mountains of various heights, obstructing perfect communication with any southern basin, unless near the higher courses of the Tobol and the Irchim. Now, secondary formations, particularly the middle ones and the jurassic, occupy these basins. Considerable alluvions, too, and even tertiary beds, fringe and there cover these last, and are chiefly met with in the basin of the Obi.—With regard to South America, similar analogies induce us to think that, if transition rocks covered by alluvium and tertiary deposits, occupy the narrowest part of that ancient strait of the ocean which separated the Andes from the former island of Brazil; some secondary rocks accompany, at least in a few places, the formations above found, either wholly or partially, the schistous crystalline soil of the Andes, Paraguania, Chile, and Peru. Travellers actually exploring these countries will, doubtless, soon definitely clear up the subject.

V.—Deductions concerning doubtful points in speculative geology, from the labours, leading facts, and various civilizations of Humanity.

1. The various LABOURS of civilization are closely connected with the geology of the country where they are performed. If, for instance, we are discussing a country of low hills or of plains, surrounded by chains of crystalline schists, such as constitute part of Asia Minor, a doubt might remain whether the heights are secondary or tertiary; but the latter will most probably be the case if the heights are cut by great roads or modes of communication. Wherever canals exist, they may be taken as a certain indication of a low division line of the waters, and of a formation in all probability tertiary. The Isthmus of Suez and its traces of an ancient canal, are an example; and similar considerations strengthen the conclusion, that a vast tertiary and alluvial soil constitutes the plain watered by the great canal from Nankin to Pekin. All the formations, indeed, even when they rise into lofty crests, leave passages for roads; but whilst in an elevated crystalline or secondary chain, roads are rare—communication being there restricted to certain *cols*; quite the contrary is the case with the transition or secondary horizontal rocks, and especially with the low tertiary hills. The number of towns and villages that our modern travellers tell us of the caves of troglodytes, and of excavations either for dwellings or temples; for it may be at once inferred, that these are calcareous caverns naturally enlarged, or holes dug in friable, probably tertiary sandstones, or in basaltic tuffs, trachytes, pumice, or even, as with some of the pagodas of India, out of granitoid rocks. Now a single and apparently indifferent and unconnected detail, will often enable us to choose among these various possibilities.

2. M. Boué dwells at considerable length on the effect of the physical conformation of continents in modifying the intercourse, mixture, emigrations, and warlike enterprises of different tribes and nations; and on the manner in which these rather appear to receive shape and direction from it, than to be capable, in our present state of knowledge, of throwing definite light on the structure, whether geographical or geological, of unknown portions of the globe, we omit his observations.[*] There is more direct interest, however, in his speculations concerning the distribution of the varieties of the human race over the earth's surface, for although not prepared to assent to his hypothesis regarding a diversity of Race, we find no difficulty in agreeing, that the farther back we go into the twilight of the past, the probability is the more forcibly impressed, that the seats of the earliest discernible civilizations, were the mountainous parts of the several continents, from which the diverse tribes descended and diffused themselves gradually, as geological changes permitted the flat lands to be habitable: so that the history of the human race is remarkably connected with the most important of recent geological changes; and, rightly interpreted, may become their index.

a. The *early* seats of the NEGRO RACE were unquestionably in the African triangle south of the Sahara; and the same circumstance that confirms the supposition, that this race was then separated from the White varieties on the north, by a vast sea; which certainly would not have been so likely had Negroes been found on the southern coasts of the present Mediterranean. On the retreat of the great ocean filling the Sahara, &c., the population descended from the heights of Abyssinia, by means of the valley of the Nile, as far as its Delta, and by the Abyssinian ports of Arabia and Hindostan, formed the great Hindu-Negro people by whom the Egyptian civilization was unfolded. The mass of the Negro race filled up Africa south of the Sahara, taking on the civilization of the Bechuanas, the Hottentot, and the true Negro of the centre, in obedience to those conditions of soil and climate which are found acting with the same effect on the Negroes of Brazil or the Red Indians of the north, and their compatriots in the Andes of Peru and the Mexican plateau. The factor another black or bronze race being found in part of Australasia, along with peculiar animals and vegetables (where, however, the fossil bones of the *elephant* are found mingled with those of the kangaroo), seems—in spite of our human history—to fix a geological date for the separation of this continent from Asia.

[*] M. Boué's remarks, however, being calculated to throw light on other problems which may receive elucidation in the course of the publication of the "PHYSICAL ATLAS," and possessing, besides, an intrinsic interest, we subjoin an abstract in this note.

It is not easy to overlook that the distribution and civilization of the different tribes and races are determined essentially by the configuration of continents. Configuration of continents, which now presents the most striking anomalies of the globe, we are first struck by the existence of nations forming a compact single mass, with very few analogies with the tribes beyond their territory. In this position we find, in the first place, many *islanders*, as the inhabitants of Great Britain and Ireland, Japan, separated from the continent by considerable distances, or by considerable seas;—the Scotch, for instance, have been thus divided from the English; the Norwegians from the Swedes; the Spaniards from the Portuguese; the Italians from their neighbours; and the Greeks from the Slavonic tribes. So, on regarding this last mass of separation more minutely, we find that *mountain chains*, when *direction* is nearly from east to west, *confine* different races within nations of the same kind. From north to south, on the other hand, of mountains *divide*. This law very visibly affects the distribution of the Sem and Semi of the globe; but it is also quite marked through the whole history of mankind. The immense wall of the Scandinavian Alps, for instance, has been no barrier to the circumstance that the Scandinavian nations by people connected with the Germans, whilst the Finnish race, dividing England from Scotland, and the moderate elevations of the Highlands of Scotland, have, for centuries, and notwithstanding the most powerful means of civilization, hindered the amalgamation of the Celtic and Gothic races. Something not dissimilar may be remarked as to the Franks and Belgians, although the elevation separating each people is more insignificant. The Alps, the Pyrenees, the Caucasus, and Italian Alps, the Spanish Sierras, or, indeed, on the other side of east and west chains, then the inhabitants of Spain do from the Portuguese, or the Piedmontese from the Provençals. Of the Alps, the Caucasus, and more striking differences between the Germans and Sclavonians, the Tartars and the Chinese; or between the Tartars and the Hindoos; then between Persians and Persians; or Hindoos and the tribes on this side of the Indus; while in South America, where the north and south direction characterizes all the chief chains, the same result has been more striking. For this reason, the Spaniards have not revolted more from Europe and Africa, or even their Asia and Australia united. Another specialty characterizes chains running north and south, as the Andes, the Rocky Mountains, and the Alleghanies, and that is the *isolation* of the people whose chains stretch from east to west. From Poland, for instance, one passes insensibly on through *intermediate steps*, on going from the Sclavonians beyond the Danube to France; while, on crossing the Pyrenees, or the Alps, or the Apennines, we find separate tribes and different languages divided by a single mountain. In the same manner, in many points in Turkey in Europe we insensibly reach the Slavonians from Albanian districts; but, especially south of Macedonia, the Greeks are separated from the Slavonians by the Balkan. For this reason, the Spaniards have little sympathy with the Italians, and have therefore the same hardly accomplished the conquest and colonization of the northern half of the New World, while in the region south of the Isthmus of Panama, the same circumstance has favoured the colonization and dismemberments of the Spanish States, to an extent that first ground to the conquerors, that the Northern Republics will not be content further to the south. The same principle has occasioned incessant changes and consequent ruin of many of the pages of history, and modified war and conquest; for there have never been more easy in the direction of north to south, than east to west, conquests. Other illustrations might be found, as the rapid conquests of Asia, were ever able to cross east and west chains with absolute security; the Cimbri were cut to pieces by the Romans after they had ingeniously passed the Alpine barrier between them and their country; the Romans conquered Germany, but could not maintain it; they conquered the Alps themselves, but could not bring into the Roman countries: the Goths were arrested in the Eastern Empire, by ridges in the direction of the parallels of latitude; and history records the most remarkable instances of their struggles in Spain, between the Visigoths and the Arians, and, after unless from Africa; the Magyars penetrated into Hungary by the north and south portions of the Carpathian chain, viz., the Marmarosch and Eperies; but were greatly aided by the circumstance of his expedition, which generally went from west to east: in the thirty years' war, the Imperialists had the great good fortune of operating behind chains lying in the same way; and the small chain of Arminius is famous in history by the bloody wars which have so often devastated Belgium. And, lastly, the Russians owe much of their success in the conquest of Asia, to the valley of elevation of Asia, of the other class explain Napoleon's disasters in Spain; they pushing the war in Algeria; they protect the Greeks against the Turks; and they ensure the independence and independence of the Swiss. The formation of small independent tribes in the Caucasus, the Pyrenees, and some parts of the Swiss Alps, obtains its explanation also in the class of considerations.

Ethnographic phenomena are thus, in all their general features, closely connected with geographical; and though we cannot extract it necessary to employ them to guide us to a knowledge of the latter, it is clear that the converse is sufficiently close to aid the geographic historian, in his largest conjectures, as to the future destiny of Races, and the course of civilization.

III.

I. INDICATIONS OF THE GEOLOGICAL STRUCTURE OF A REGION, DERIVABLE FROM THE SPECIALITIES OF ITS OROGRAPHY.

1. Views any complete section, either of a mountain chain, or across a continent, the structure of the prolongation of that chain or continent may generally be safely inferred.

Mountain chains and continents being frequently interrupted by changes *posterior* to their formation, the series of rocks of which they are composed is not terminated by these, but stretches across the interruption. For instance, almost all the straits and channels of the ocean are, like the beds of rivers, only clefts, or cavities of erosion; and therefore we usually recognise on both sides, the same strata: Thus, while we find in the north-west of Ireland and the Orkneys, the formations of the Highlands of Scotland, while the north-east of Sicily corresponds with southern Calabria; while Corsica is prolonged into Sardinia; while the same rocks form the two shores of the English Channel, as they do those of the Red Sea, and the opposite sides of the Strait of Gibraltar; the formations of Turkey in Europe pass in the same manner into Asia Minor; those of the Crimea into the Caucasus; those of Eastern Persia into Beloochistan; and those of Cuba into Jamaica. Thus also, the Straits of Behring separate similar ancient beds; and those of Bab-el-Mandeb are a mere volcanic rift which has torn the principal chain of Central Africa from the old crest of Southern Arabia. The greater number of our large islands are connected in the same manner, and for the same reason, with continents. For instance, the transition and schistous rocks of Norway are prolonged under the sea to Spitzbergen; the formations of the Oural Mountains stretch towards Novaia Zemlia: the transition series of Russia is found in the Baltic in Dagoe, and Oesel; and the recent secondary rocks of Eastern Spain reappear in the Balearic Islands. Similar relations exist between the ancient chain of Olympus and Pelion, and part of the islands of the Greek Archipelago; between the secondary system of the Peloponnesus, and the Isle of Crete; between the coasts of Asia Minor, and Cyprus, Rhodes and its other littoral isles. The island of Socotra being only the prolongation of the nearest headland of Africa, partakes, in all probability, of its geological structure; Ceylon may resemble its neighbouring district in Hindostan; Tierra del Fuego must be a prolongation of Southern America; and Van Diemen's Land will correspond with Australia. So also, the island of Trinidad has a close physical and geological connection with the coast chain of Cumana; the isles of the Gulf of St. Lawrence, with the neighbouring continent; the numerous islands in the Arctic Seas, with the northern portion of North America and Greenland; the chains of Yechin-China and Siam, with those of Pegu; the mountains and deposits of Kamtschtka, with the Japanese Islands; and the secondary beds of the Lena with those of New Siberia. Much light might thus be obtained regarding the configuration of considerable portions of the *bottom of the ocean*, as well as with respect to their geological structure—a study as interesting and important in reference to the geology of the globe, as the careful measurement of its whole accessible surface; but in the present imperfect state of our knowledge, an attempt at definite delineation were in this case hardly justifiable.[1]

2. The correspondence of mountain chains in regard of DIRECTION *evinces resemblance in geological constitution.*

This most important fact in the structure of the Earth, presents itself under two aspects.—

A. When the chains are parallel.

The law in this case is a corollary from an ingenious theory of the Elevation of mountains (see parts B and C of this disquisition); but altogether independently of theory, it is a certain geological truth, that generally the same structure may be predicated of parallel chains, separated by arms of the sea, straits, or valleys, by igneous deposits, secondary or tertiary basins. As examples of chains separated in the way first noticed, we have the farther Hebrides, and the north of Scotland; Cornwall, Brittany, and the north-west of Spain; Sweden, and Finland; Morocco, and the south of Spain; California and adjacent America; the Peninsula of Malacca, and Sumatra; New Guinea and the north-east of Australia; the south-east of that continent, New Caledonia, and New Zealand; Madagascar, and the neighbouring part of Africa. With regard to parallel chains separated by the other modes, we have instances in the Jura of France and Switzerland, and the Himalaya; Celestial Mountains; the chains of Western Servia and Bosnia, &c. &c. Now, if the proposition is thus found true in all countries which have been examined geologically, we may trust to it in the case of districts still unexplored, and receive without hesitation what it enables us to predict. In the case, however, of chains not well known geographically, we shall be apt to hazard erroneous conclusions, through mistakes with regard to their *exact direction*.[2]

B. When the chains have identity of direction, although not parallel.

Because of the sphericity of the Earth, remote ranges of mountains with identity of direction—that is, which stand in the same relation to the north or south points—will not be parallel, but convergent; but that they correspond, nevertheless, in geological structure, the phenomena of the following characteristic groups abundantly testify.

a. Direction, W. to E. nearly. Many remarkable chains belonging to this group are clearly identical in geological constitution, viz., the principal chain of the Alps; chain south of Transylvania; the Balkan; Taurus; Propontamus; Hindoo Koosh; Kuenlun; Himalaya; Celestial Mountains; the Imschan; the great chain in Central Africa (probably); the Parima in South America; the coast chain of New Grenada; and the submarine chain which forms the base of the volcanic and madrepore islands of Oceania.

b. Direction, N. to S. The following chains, stretching from north to south, exhibit an identity of ancient and transition formations, of igneous deposits, of metalliferous veins, as also in most cases of certain dependent secondary strata, viz.:—Caution crests in the north of England; part of the Norwegian Mountains; the banks of the Middle Rhine; Central France; Corsica; the Jural; the chain of Kamtschatka; Eastern Altai; the chain of Sudetes; their middle east of the Yenessei and the Lena; Cordilleras in New Mexico, Bolivia, and Chile; chains on the west coast of Southern Africa, and in the Peninsula beyond the Ganges.

c. Direction, N.E., S.W. nearly. Striking geological resemblances here again meet us, notwithstanding the distance between the corresponding ridges. As examples, we have the mountains of Ireland and Scotland, of Scandinavia and Finland; chains on the banks of the Lower Rhine; chains in Saxony; Bohemia; the south of Spain; mountains to the north and south of Kokan; the Ala Dagh and Ak Dagh; the Altai and its eastern dependencies; chains in Southern China; the Eastern Ghauts; chains between Herat and Candahar; the chief Alleghanies; the Ozark Mountains; chains in Columbia and Brazil; chains in the south-east of Australia, as well as in the south-east of New Zealand. This group is characterized by the same ancient schistoms rocks, the same transition formations, the same porphyritic or dioritic masses, and the same description of metalliferous veins.

d. Direction, N.W. to S.E. nearly. Lying in this direction are the following mountains, widely scattered over the earth, but closely corresponding in their ages, secondary, and tertiary deposits, their peculiar igneous rocks, viz.:—serpentine, diorite, euphotide; and their metamorphism, which is also peculiar, viz.:—*serruenus*, marble, gypsum, &c.; viz.:—parts of the northwest of Germany, and of the Apennines; the lower parts of the Spanish Pyrenees; western chains of the Greek Peninsula; Eastern Carpathians; chains of Crimea and Caucasus; ridges bordering the valley of the Red Sea; its granitoid and schistoid banks; the western and eastern chains of Syria; a chain between Mesopotamia and Persia; chains west of Herat; others in Tartaria; the Western Himalaya; Karakorum and Kaflehi; mountains in Cutch, ridges in Mexico, Guatemala, and Cuba.

e. Direction, N.W., E.S.E. nearly. This fifth group, composed of crystalline schists and massive crystalline rocks, comprises the Riesengebirge; Rhodope; Central Pyrenees; the Ballons of Vosges; mountains in Brittany, Western Alleghanies; ridges in Canada, south of the Great Lakes, &c., &c.

f. Direction, E.N.E, W.S.W. nearly. The chain of Vindhya in the north of Hindostan; certain chains at the southern extremity of Africa; some in Spain; and also the Hundsrück; present, along with uniformity of direction, a corresponding structure, chiefly of transition rocks.

g. Direction, N.N.E., S.S.W. nearly. This more numerous group consists of part of the mountains of Northern Africa; of the western Alps; Western Carpathians; chains between Transylvania and Hungary; certain chains in Spain; ridges of South Calabria and in Sicily; the high Atlas of Morocco; certain chains in the Andes of New Grenada; coast chains in Brazil; chains in Chinese Daouria and Mantchouria. All these exhibit the cretaceous formation, upheaved on crystalline schists and granitoid rocks; and in some places even the tertiary soil is disturbed. The chains in which the whole of these features do not appear, are coast lines whose sides have probably been subject to extensive *denudation*.

h. Direction, N.N.W., S.S.E. nearly. This group is composed of similar very ancient rocks, and includes the two great chains of Arctic America and their parallel dependencies; part of the Andes, and of the Cordilleras of Western Brazil; the Western Ghauts; chains in the Peninsula beyond the Ganges; the Bolor, &c., &c.

M. Boué might have greatly extended his lists under each of these groups; but enough is adduced, to exhibit the existence and illustrate the character of an apparently primal law amongst the revolutions of the Earth; and to enable the geologist to venture, in comparative security, opinions concerning the structure of countries that have not been individually explored.

3. Inferences from the different HEIGHTS *of Mountain Chains.*

When a lofty ridge is flanked by parallel chains much lower than itself, as well as by plains, we shall generally find that it consists of an ancient central mass, with associated secondary and tertiary formations. Thus owing to the similarity of the physical structure of the Alps and the mountains of Central Asia, we are enabled to presume that the latter—like the former—exhibit, central chains of crystalline schist without transition rocks, with lateral chains of recent secondary masses; then small hills of molasse or tertiary rocks separating these schists from plains, or the basins of great rivers; and finally, streams watering isolated tertiary basins. Now, this is exactly the arrangement of the masses in question; and the discovery has astonished those who give no credit to geological predictions, and who have never observed the majestic harmony of the geographical distribution of the different formations over the globe. In the same way, comparing the analogous chains of the Ouural, and of the two Americas, we might suspect here and there beds of secondary and tertiary deposits, at least on the eastern slope of the Rocky Mountains. The waters of this chain carrying down alluvium beyond its valleys, would originate deposits, which, on account of the nature of the north part of that continent, would probably arrange themselves under forms parallel to before mentioned; and as the chain extends during the tertiary epoch, we are therefore not surprised to find tertiary beds, molasse, lignites, &c., towards the mouth of Mackenzie River, and also at some other points near the eastern foot of the mountains.[3] Other striking examples may be found connected with the physical and geological geography of Syria, Mesopotamia, Persia, and Arabia.

4. Indications afforded by the general aspect of mountains, or of their DECAPITATION.

This feature of mountain chains frequently attracts the notice of the traveller who has an eye to the picturesque; and very often valuable geological inferences may be drawn from his descriptive sketches. Thus, as blunt cones with craters indicate volcanoes; a series of peaks like a saw denotes diluvium; rounded peaks like the tops of vails chatterine calcareous rocks; triangular points, slates or quartziferous schists; needles, crystalline schists; capricious twistings and crumplings, serpentines and trachytes; pyramidal forms, phonolites, &c., &c. Thin and dark-looking walls intimate the presence of basalts, trachytes or traps, as on certain coasts of Greenland, some of the Arctic islands, and the north-west of Australia. Rocks broken up by the weather into roundish masses are granites or grits, or, more rarely, traps. If, in a district of a greenish hue, we find white rocks spotted with black crumpled masses, we may suspect the existence of diorites or basalts in a calcareous soil; but if the green rocks are isolated, they are probably serpentines. Many other suggestive details might be deduced from a full analysis of the natural configuration of rocks.

II. GENERAL PRINCIPLES OF DEDUCTION CONNECTED WITH HYDROGRAPHY.

1. The phenomena of RIVERS *are highly instructive in theoretical Geology; although they do not exactly fall under definite laws. Their chief bearings and importance are unfolded in the following remarks:—*

a. The different Formations present very striking contrasts in regard of their POTAMOGRAPHY, mainly owing to the very different proportion of surface occupied by their valleys. The river courses of the crystalline schistous soil, are characterized by their great extent—the number of their bifurcations and of their undulations; such, for instance, are the courses among the Central Alps, in Brittany, in Brazil, among the chains between China, Tonquin, and Cochin-China. In calcareous soils these courses are much less frequent and less undulating; many of the valleys are dry, or have waters which soon lose themselves—rivers even, being engulfed beneath their cliffs. The potamography of Western Arabia, alone, denotes the prevalence in that region of a calcareous structure. The hydrography of the tertiary basins, likewise differs much from that of the chalk, of the jurassic formations, or of the secondary sandstones.

b. Great Rivers have, for the most part, at their *mouths, extensive deltas of alluvium*, usually traversed by several of their branches; so that, knowing the nature of the deltas of the grand rivers of Europe, as well as of several others belonging to other continents, such as the Nile, the Senegal, the Niger, the Gambia, the Indus, the Ganges, the Volga, the Lena, the Yenessei, the Obi, the Mackenzie, Mississippi, Oyapok, and the La Plata, we may conclude with equal certainty that similar alluviums characterize districts at the mouths of the Amoor, the Sir, the Kistna, the Godavery, the five great rivers in the peninsula beyond the Ganges, the Blue and Yellow Rivers of China, and the rivers in Siberia; so also with the deltas of the Zaire, the Orange River, and the Zambeze in Africa, those of the Amazon, the Orinoco, the Rio del Norte, &c., in America. There are, however, distinctions in regard to these deltas. Rivers that escape suddenly from an escarpment of rocks bounding the sea-shore, have no deltas, properly so called, but carry their alluvium on into the sea, and deposit it beyond the line of the shore. Such, for instance, is the case with the rivers that stream flowing into the Atlantic (high land bounding its coasts almost in every part), while the contrary holds with those which, from the west continent, flow into the Atlantic Ocean.

c. As tertiary deposits also accompany the *courses* of all great rivers behind whose deltas or embouchures considerable plains or extensive valleys are situated, we may infer that such deposits exist in those which have surveyed only by the geographer. Here, however, the risk of error, we may map down the locality of tertiary formations in Africa, along the Senegal, the Gambia, the Orange River, the Zambeze, &c.; in Asia, on the Kizil Irmak, the Kour, the Euphrates, the Amoor, the Sir, the Indus, the Ganges, the Brumpooutra, the Irawady, the Menam, the Me-Kiang, the Sang Koi, the Blue and Yellow Rivers in China, and the banks of the Obi in Siberia. The same holds in America, for the rivers of Eastern Mexico, those of the north-east of Brazil, the Magdalena, the Orinoco, the Amazon, and the La Plata, as well as for those of the Pampas and Patagonia. The fact, indeed, is already placed beyond doubt with regard to many of the rivers just named. Analogy may also lead us to infer that the great alluvial and tertiary plains of the lower Danube, of the Pampas, and the lower Mississippi, have their distinct analogons on the banks of the Amazon, of the lower Ganges, and in the country between Pekin and the Yellow River; and from the nature of the deposits in the first named localities, the banks which characterize them, and the kinds of their formation, we are enabled to infer similar facts in regard to the kindred beds in these other countries which are much less known.

d. In some probable, *à priori*, that all tertiary basins on the shore, especially such as have no barrier towards the sea, include *marine formations*, or lagunes of salt water, rather than deposits resulting solely from fresh water; whilst the contrary is probable in the case with such basins far inland; and one may predict, with considerable certainty, where these salt-water deposits will be found, and where the detritus of ancient inland seas or great lakes. This it will one day be discovered that the African Sahara, with its salt deposits, is the bottom of an ancient Mediterranean Sea; and that the other tertiary deposits on the shores of that continent, are marine. The desert north of the chain of Atlas, and that of Gobi, are, on the contrary, for the most part fresh-water formations, &c., &c.—The basins of almost all plains which are elevated, or remote from the sea, are generally tertiary deposits of fresh-water origin; but previous to drawing this inference, it is necessary to examine with care the levels of the neighbouring gorges, or communications with the seas. With regard, to the Hungarian Tertiary basin, it is at once evident that it is at once above the surrounding levels, that when it was occupied with water, the Black Sea probably beat against the base of the Balaco-Servian chain, and must have communicated with the interior sea of Hungary by a large arm, occupying the valleys of Temok and Morawcha in Servia; and so of other localities.[4]

e. Again, the characteristics of rivers are distinct in consequence of variation in the nature of the formations through which they flow, as well as of movements undergone by them. This law holds with small rivulets as well as large streams; for if a rivulet meet a *dyke*, or in any way passes from one formation to another, its course is changed; and precisely in this manner the great bendings of all large streams seem brought about. As instances, we have the curvatures of the Rhine at Basel or Bingen, of the Rhone at Lyon; of the Elbe in Bohemia, and near Dresden; of the Danube beneath Regensburg, and between Gran and Ofen; of the Dnieper, the Dniester, the Don, the Obi at Obdorsk; of the Euphrates, the Nile, the Orinoco, the S. Francisco in Brazil, &c. The law thus as general, or rather universal, in regard of countries whose geology is known, may be safely extended to others of which we know only the geography; and hence valuable indications from the course of the Niger, from the rivers of Upper Hindostan, of Tibet and Tartary, from the bendings of the Yellow River, from the twists of the Rio del Norte in New Mexico, and of the Colombia, the Colorado, the Parana, &c. The operation and universality of this law will be fully illustrated by a glance at the map, where the conjunction of the bending of its course with a change of strata is emphatically exhibited in the case of every important stream.

2. The existence of LAKES *in a country, their form, and the system of rivers connected with them, constitutes another source of indication in regard to its geology. We have first well marked and easily-discriminated species of lakes.*

a. Besides those small lakes, characteristic of every mountainous country, which are merely collections of water in accidental hollows, we have *cratériform lakes*, arising in peculiar actions, and belonging exclusively to certain formations. If these are in plains or valleys, without visible outlet, they must be regarded as the result of sinkings (*affaissements*) in the cretaceous gypseous masses, secondary or tertiary; but if they are surrounded by a crest of elevations, they are true *volcanic*

[1] At present, indeed, we can only venture to suspect that the bottom of the ocean presents a hollow when configuration has a general resemblance to the *relief* of existing continents. For we are in the habit of considering the seas established by our soundings—indeed by far too few, and for the most part taken too near the coasts—that the greatest depths of our seas do not surpass the altitudes of our loftiest mountains; that certain seems are deeper than others, the larger ones being in general the deepest; that on the ground of these data, we have ventured on constructing artificial maps of the bottom of the seas of Europe, and of some other points of the globe's assumed surface, especially our coast counts, of great and probable correctness in navigation, but how many data are requisite to give certainty even to those very general deductions? And how many important problems remain unresolved, or rather not even undertaken! What, for instance, must observations on the temperature, previous to being able to pronounce on the following questions, the identity, or only the approximation of contour between the reliefs of the continents and of the bottom of the ocean; the direction, branching, distribution, and configuration (probably wholly peculiar) of submarine valleys and gorges of elevations; the probability of the non-existence at valleys at great depths; the presence in other places, of vast craterriform basins, the sort of debris, slopes, and encirclements, as well as the localities of true submarine valleys or the beds of currents; the formation of the upper part of the bottom of the ocean which are peculiarly not covered by deposits; the appreciation of the geological formations which cannot be found there; the knowledge of such as exist, their distribution and their thickness; the direction of formations which probably have never emerged, from such as have passed the surface of the waves to be again engulfed; the different deposits which have formed, or still are forming, at different depths, or near the shores; the diversity of these last in different zones and climates of the globe, &c., &c. As the waters cover the greater part of the earth, it is manifest that, even were the existing continents thoroughly studied, we would still be very far removed from a satisfactory acquaintance with our globe.

[2] It is necessary to remark, that to all speculations similar to that now sketched by M. Boué, the element of DIRECTION, as that on which the whole hinges, must be accurately, and not merely approximately determined. Now, as the long axis shown by the direction of a chain, or the general feature connected with it, were fairly to pretend that the direction of the chain referred to in the text has been ascertained with even an approach to the suitable accuracy; and hence one important cause of the diversity of conclusions arrived at by eminent geologists regarding their plans and age.

[3] It is necessary to observe, that the mere existence of a large basin is not always sufficient ground for the conclusion that it is occupied by a secondary or tertiary soil, for a very ancient formation, whose constituents are quite different, may assume the form of a hilly platform or plateau in the midst of mountains. Examples are to be had of such plateaux formed of highly inclined schists, cut horizontally, as if with a knife; for instance, in the Ardennes of Brittany. Some flat steppes are composed of horizontal secondary limestones, and some on the banks of the Orinoco of secondary sandstones, in no wise to be confounded with tertiary *molasses*. Basin in Europe furnishes a striking example of the possibility of being deceived when deducing geological conclusions from the existence of low basins, for the enormous plains of Hungary, are mostly composed of immense horizontal beds belonging to the transition epoch. Nevertheless, in cases like this, other connected circumstances easily enable us to ascertain the true state of things.

[4] Now, the true line of direction referred to in the speculations in the text, is the first and third,—strictly speaking, perhaps the third only. It is the line along which the force has been exerted to which the elevation is due; and, in most cases, may be that lying at *right angles to the direction of the axis of the ephemeral strata*. We were fully to pretend that the direction of the chains referred to in the text has been ascertained with even an approach to the suitable accuracy; and hence one important cause of the diversity of conclusions arrived at by eminent geologists regarding their

important, and that the ranges belonging to it increase in number as we approach the equator. This fact, attributed by M. Boué to the greater centrifugal force at the equator, is unquestionably characteristic of the earth's present condition; for around the equatorial protuberance we find a broad belt of chains of the first order, running east and west, viz., the central chains of Africa, Europe, and Asia; the submarine ridge, whose crests still appear in Oceania; and the coast chain of New Grenada and Panima. In fact, all the great protuberances of the globe, whose reality is established by the pendulum and geodetic measurement, as well as the most elevated summits, lie parallel to the equator; and alongside of these, other lines may be traced, distinguished by enormous *screwlements*, or series of gulfs, seas, lakes, or terrestrial basins of a very low level:—accidents which are the natural result of the extraordinary spheroid of the neighbouring zones. It certainly is not unlikely that this very striking feature may indicate, with a rude though impressive touch, that the rotation of the globe on its axis has modified and co-operated with the interior forces, in producing the existing forms of its surface.

In the course of the previous remarks reference has been frequently made to the law, that *correspondence in direction indicates correspondence in constitution*. Now, it must be repeated, that the correspondence signified by M. Boué, does not necessitate absolute parallelism, unless the chains are in each other's immediate neighbourhood; but simply that each chain is similarly related to its own north. According to him, every formation of mountains has taken place on the globe along lines not mathematically parallel, but which usually *approximate to great circles of the sphere*: and he is hence led, with the illustrious Humboldt and others, to conceive that these chains result from the *cooling of the globe, modified in its effects by the various forces acting on the matters of which the globe's crust is composed*. If we believe that the earth has reached its solid state through a continued refrigeration, it must appear much more rational to suppose that in the course of the successive contractions of the oxidized crust, the envelope has, in its efforts to follow it, broken or split along parallel portions of great circles, than that these splits have taken place *capriciously* in all directions; and in fact this occurs even with large molten scoriaceous masses that cool slowly: and in the edges of such clefts or splits, with the still incandescent masses poured through them from within, we should then have the origin of mountain ranges. Possibly, however, a more extensive view of the subject may not confirm the fundamental hypothesis. It assumes as quite essential, that *the earth's solid crust has continued comparatively thin* during the whole range of geological changes of which any memorial is left; and this is certainly not upheld by the only positive light science has hitherto cast on the subject—the light obtained from a physical consideration of the precession of the equinoxes: nor, although the utmost variety must be allowed to the actings of Nature in the sphere of her grander forces, can it fail to seem startling, that among the multitude and variety of elevations discernible in the Moon, there is no trace of an arrangement referable to such a law. It may appear prudent, then, still to regard the causal part of this speculation with a due mixture of doubt.

III. A few interesting generalizations may be connected with the mode in which the chief geological formations are distributed over the surface of our great continents. A slight survey of the map manifests the curious fact, that the compliancy of a region, in this respect, augments in proportion as its contour is broken and irregular:—thus, it may be, indicating the comparative number of upheavals to which it has been subjected. Africa and South America, whose coasts are quite unbroken, are of all the least complex; whilst North America, Australia, Asia especially with its appendix—Europe, and the north coast of Africa, form a progression decreasing in simplicity.

1. Glancing over the different geographical regions, and beginning with the POLAR; we find these eminently characterized by the rarity of active volcanoes, by the predominance of crystalline schistous rocks, of granitoid rocks, and other massive and transition deposits, comprising in the last the ancient coal fields towards the North Pole, which, however, very rarely pass the polar circle. Limited tertiary beds are found there, but they seem of an age comparatively recent, and not of all the epochs of this extensive period. The want of secondary rocks indicates the absence of those essential climateric conditions, of the animals, &c., which have concurred in the production of such formations in other zones:—circumstances which have also prevailed during the earlier portion of the tertiary period. Within the north TEMPERATE ZONE, or perhaps between the polar circle and the equator, we find secondary and tertiary beds associated, in greater or less abundance, with every transition formation: but within the TROPIC regions, considered as a whole, the prevalent rocks belong to the tertiary epochs, especially the more recent, and to the group of crystalline schists, and granitoid masses. Very few transition formations are found there, and very few coal fields;—in Africa, however, recent intelligence has informed us of one coal field near the Orange River. The ancient carboniferous rocks seem to have their chief seats between the polar circle and the tropic of Cancer, where the vegetable masses appear to have been more easily mineralized, and to have been submerged and again raised above water, amid seas of limited depth, studded with islands: while between the tropics, the heat, still too great, was unfavourable to luxuriant vegetation; and there then existed in those districts very little dry land.[1] In the few promontories stretching beyond the tropic of Capricorn, traces appear of a distribution and proportioning of deposits, not dissimilar to what prevails in the great zone north of the tropic of Cancer.

2. Of the numerous *single* phenomena, which have prevailed through all epochs of the world's history, and impressed their influence on its course, the most noticeable is unquestionably the VOLCANO. Along with all igneous rocks, volcanoes belong to every zone; but our chart shows that they especially abound within the tropics, where also are enormous masses of igneous eruptions of every age. Volcanoes at present are chiefly in action in islands or along coasts, although exceptions exist in part of the American isthmus (the line through Mexico), and in Central Asia. Africa and Australia have no volcanoes; but igneous rocks sufficiently modern, such as basalts, are found there. It will be seen, that throughout all periods, volcanoes and their products are distributed either along lines or clefts, or in circles around a grand central crater; but in the ancient volcanoes, the crater has often disappeared, leaving instead, a lake or great *circumlement*. The circular distribution seems to have been much more common in very ancient times: and several parts of the surface of the earth then bore a close resemblance to the craterifom structure of the Moon. Of such granitic rings, the best preserved are Bohemia and Ceylon, and probably the Montagnes d'Oisans: traces of the same phenomenon are found on the banks of the Middle Rhine, where, however, subsequent dislocations and upheavings have much destroyed the oval form. The granitoid rocks of Egypt, Nubia, and Arabia, are likewise disposed in apparent accordance with their original connexion with a vast circular surface. *Porphyries, trachytes, and basalts*, are everywhere easily recognised in connection with *lines* of elevation or dislocation; but they, too, are often found circularly disposed, especially if the minuter features of their distribution be observed, and minor centres of eruption looked for.[2] Turning to *granites* and *sienites*, we find them belonging to every continent, and almost every country; but hypersthene sienites, porphyries, euphotides, serpentines, diorites, trachytes, and basalts, have appeared only in certain districts. It will, undoubtedly, be one day in the power of the geologist, to divide the earth into regions, each characterized by the presence of one, two, or three descriptions of igneous eruptions; and thus to trace out the shiftings of the points from which fused masses have issued. But this, with other questions depending on it, belongs to the more difficult portions of the science.—The specialia of volcanic phenomena are elsewhere discussed at due length in the PHYSICAL ATLAS.

3. The facts ascertained regarding the *distribution of ORGANIC REMAINS* among the strata of the earth, are of high interest and importance; and enable us to hope, that at some early period a striking light will be thrown on that most mysterious and attractive of all themes—the order and laws of the evolution of Life. The following is a summary of what is now reckoned established:—(1.) That the general temperature of the surface of the globe has diminished from ancient times until now—although, perhaps, with some *alternations*—is rendered indisputable by the whole course of its flora and fauna: but it is remarkable, that in the recent tertiary deposits fossils within the tropics are found of species not identical with plants or animals at present living within that zone; although the climate existing there might seem to approach the most nearly to that of primordial epochs. Now, this indicates a *total climateric change even in the environs of the equator*; and that an *ultra-tropical* heat, most formerly and even comparatively lately, have prevailed over those portions of the globe. If we could be permitted by other considerations to attribute, with M. Boué, this great revolution to the gradual cooling of our spheroid, the ascertained laws of the rate of such a refrigeration would inevitably introduce us to durations of a magnitude, to the conception of which no imagination is equal! (2.) The higher we ascend in the series of fossiliferous strata, the greater is the resemblance among the fossils of distant countries, and even of remote zones; and these resemblances characterize not genera merely, but species. It seems probable, therefore, judging from analogy, that the external circumstances capable of modifying the forms of organized beings, have likewise, during these successive epochs, increased in complicacy: and it may be inferred further, that the cause of previous high temperatures must have been one affecting the whole surface of the spheroid, with a tolerable equality; inasmuch that the diversifying influences of solar heat was, to a large extent, counteracted by it.—But, while diversity among its organizations has thus increased as our globe's history evolved itself; the Observation of the last twenty years has fully established the fact, that from the time of the earliest appearance of living beings as inhabitants of the earth, the *complication* of their different groups, and the multiplicity of their species, very less than once was imagined from what is now discernible; and especially that, estimating them by their relations to surrounding circumstances, neither vegetables nor animals can be said to have ever assumed the *embryo* condition; but have always enjoyed a structure perfect and complete as NOW. AGASSIZ, in particular, has recently urged this doctrine with much impressiveness in his "Monograph on the Fishes of the Old Red Sandstone." (3.) In respect to the mode and order in which new species of animals have been introduced amidst the world's events, whether to expel some old race, or to supply the vacancy caused by its removal, geologists do not yet consider that definite information is afforded by our most comprehensive review of the fossil relics. It is, indeed, wholly beyond question, that a stratified rock, superimposed on another, must rank *posterior* as regards the time of its formation; but it cannot be so readily ascertained whether the deposition of this second rock was immediately and closely consecutive on the completion of the first, or whether ages first intervened, during which the process of deposition was suspended, or its area shifted to some remote locality. It is not, therefore, easy to determine whether those breaks of continuity, those *hiatuses*, which meet the paleontologist on passing from the fossils of one formation to those of the next, are intimations of destructions and creations of living species, or whether the history of life seems thus fragmentary, because leaves have been torn from its annals at repeated intervals, and for ever destroyed. Geologists accordingly are divided on the momentous question; and, it may be suspected, have encountered it prematurely. The general opinion probably leans to that expressed by PICTET—that the SPECIES of animals belonging to any geological period, have lived neither before nor after that period; that each formation has its special fossils, and that no well-defined species is ever found common to two deposits of different ages.[3] AGASSIZ, indeed, in his recent *Iconographie des Coquilles Tertiaires*, has distinctly, and without compromise, denied the identity of any tertiary fossil with a living species; but notwithstanding the dictum of this earnest and admirable naturalist, one may be permitted—on studying the *Fauna Siculonsis*—to reflect on that beautiful manifestation, of an Order connecting, through insensible shades, the past with the present; and to suspend, in the meantime, a final judgment, regarding a point so intricate and withal so momentous, in the Theory of the Earth.

IV. A brief view of the *changes experienced by the oceans and inland seas, from the most ancient times until now*, will fitly conclude our survey. This subject belongs to the grand and final problem of geology—the rational termination of all its researches; viz., the history and evolution of the GEOGRAPHY OF THE EARTH: and, notwithstanding their inevitable imperfections, our contributions towards its solution, are yet pregnant with interest.

1. We shall notice first the phenomena of the TERTIARY EPOCH. Then, as the map shows, the *Mediterranean*, or another great and corresponding inland sea, covered the deserts of Sahara, Lower Egypt, and part of Arabia; for not till long after were its present contours defined, and its lagunes and ancient shores thrown dry. Later still, the Strait of Gibraltar probably continued shut, and the waters of our inland sea mingled, through the channels of the Red Sea and Persian Gulf, with those of the Indian Ocean; which seems to explain the analogy of the fossils of the middle and higher tertiary Mediterranean beds, with creatures still living in the Red and Indian Seas, and with petrifactions, of corresponding age, in the great basin of the Black Sea and Caspian. At the same epoch too, the North Sea and the Baltic spread over the plains of Northern Europe: and another ocean, whose bed is indicated by the yellow colour on the map, stretched from the recesses of Siberia, and joined with the Mediterranean, by the Black Sea. Asia Minor contained small isolated basins; though the Black Sea, on the south and east, was confined by its present banks. In the south of Asia, a broad strait severed British Hindostan—then a triangular island—from the chains of the Himalaya and their dependents; and there existed also, four great basins in the peninsula beyond the Ganges—two at least in China, one on the banks of the lower Amour, and two others in Siberia. As, in the case of Europe, the centre of this continent was covered by an inland sea, which has now wholly disappeared; other aqueous masses covered Persia, and probably formed—

[1] Some tropical parts of the Andes are exceptions; which is a strong reason for assigning a great age to part of that chain—the portion lying along the same line as the great east and west ridges.

[2] There is a very striking analogy to this, quite common in the Moon—a long ridge, or furrow, being often visibly the result of an obliteration of innumerable small craters, which of course diffuse around them, probably by minor rents, their products arranged in circles.

[3] Amid the laws presumed as general, on this very difficult subject, the following are perhaps the most important. They are formally stated in the memoir, by Sir R. Murchison and Professor Sedgwick, on the older deposits of North Germany—a memoir, in so many respects of high importance:—1. The species found in a great number of localities, and in very distinct countries, are almost always those which have lived during the formation of several successive systems. 2. The species that belong to a single system are rarely observed at great distances; and then they constitute local fauna peculiar to certain countries. More briefly—extensive geographical distribution is synonymous with persistency through time. M. Boué has not pronounced on these laws in his treatise; and the reader is here requested, once for all, not to attribute any doubtful opinion in these notes to M. Boué previous to searching in his own excellent and easily accessible dissertation.

b. The varieties of the WHITE and YELLOW RACES, their differences of form, character, of language, and distribution, are wholly interwoven with geographical features which define the extent of their dwellings, and the diversity of their zones; and with the important geognetic fact, that the continental masses they inhabit *have always contained more or less* united, notwithstanding the existence of great mediterranean seas that have now disappeared. The enormous ridge of Asia, the comparative insignificance of the Oural, the hollow between that chain and the Caucasus, the dependence of the north of Africa on its great Mediterranean system, seem to be the chief causes of the dispersion of these fine races. Their varieties result quite naturally from the great number of chains from east to west in the continents they occupy; and from the numerous isolations produced by the intersection of chains from *north to south*; the former impressing the character of the *race*, and the latter, originating small divergencies—the efforts of time and climate. All existing researches relative to the languages of the white races are favourable to the general ideas now expressed; for the myths of the Chinese, Hindoos, and Egyptians, speak with equal force concerning the descent of the populations from elevated localities, and their gradual occupation of countries formerly under the waters.

c. In the phenomenon of the ESQUIMAUX, living within the circle of polar ice, and in a constant struggle with nature, we discern elements for a final geognetic conclusion. This singular family, so superior to the Negroes, most certainly have become associated with the unfortunate country they now inhabit through terrestrial changes of great importance. There are no highlands now near them, or any favourable centres from which they could have spread; and our only probable conjecture is, that they arrived there *when the climate was less rigorous than now*. To what epoch, then, can this event belong? Without doubt, the vegetables of the polar transition zones indicate a period at which the temperature of the poles was tropical; and when, for the light of the Sun during their long nights, there must have been substituted as an equivalent, Auroras far more frequent, more brilliant, and more enduring than those of our time. This particular condition of Nature at the poles must have diminished insensibly; but there seems reason to conclude that, even after the tertiary epoch, quite another than the present distribution of heat prevailed over the globe. The remarkable changes that have occurred in Greenland and Iceland during historical times, may even induce us to infer, that at a period not far antecedent, the polar regions were not so frigid as to drive back any human being. Now, the abundance of fishes in these seas, and the existence of useful animals, with the absence of beasts of prey, would, in conjunction with a climate usually mild, have been reasons perfectly sufficient to attract inhabitants; who, once acclimatized, may have gradually become fitted for those hard conditions which, through slow cosmical changes, have grown up around them, and which they now endure. Geology and geognosy thus do not tend to maintain all the distinctions of the zoologist; but rather contract the number of types from which varieties have sprung, through effect of change and time.

IV.

The considerations are thus manifold, on the ground of which the careful and conscientious inquirer may accomplish the transition from the Physical Geography to the Geognosy of an unexplored district, in a manner true at least in the main, and, in so far, anticipating discovery; and these presumptions may be converted almost into certainties when we have obtained *exact, and even detailed notions concerning the constitution of the countries surrounding the unknown oasis*. It seems scarce necessary to recall the fact, that every geological survey of an extensive region, consists, to a large extent, of this description of deduction; that is to say, after having ascertained the mineralogical constitution of a portion of a chain of hills or mountains, or even of a plain, we feel entitled, while following up exact geographical sketch of the accidents or peculiarities of the soil, to consider as entirely known, that of which we have really examined only a very small portion; or, in other words, to fill up, through analogy, the unexplored portions, and thus connect together the stations that have been visited. Now, we presume only to apply this same process to a theoretical exhibition of the whole globe; and instances abound in which it has been found successful. It required, for example, only the knowledge that calcareous formations of the *cretaceous* period exist in Egypt, to render it highly probable, that a similar soil prevails in Arabia and Palestine, where these are calcareous; and this almost involved an identity of the tertiary beds of the three countries. Again, long before the lower basin of the Euphrates and Tigris had been actually studied, M. Boué found no difficulty in declaring, from the structure of Syria, that it consists of tertiary strata, surrounded by very recent secondary rocks; and the vallleys to the north of the Taurus, watered by the Frat and the Murad, indicated tertiary basins of a high elevation, previous to the discovery there, by the Russian engineers, of saline deposits of that epoch. Thus, likewise, on ascertaining that the tertiary plains of Mesopotamia are partly bounded by cretaceous mountains, it became probable that this system also includes certain ridges along the eastern prolongation of the Taurus; which have obtained, in this case, an unusual altitude, in consequence of the east and west direction of the central Asiatic protuberance, and the crossing, in that place, of other systems of elevation from north-west to south-east. But, since *the* chains between Mesopotamia and Persia have been ascertained, is it not evident—the two sides of a transversal valley generally offering the same deposits—that we can already judge roughly concerning the strata which, towards the east, bound the ancient and gramitoid soil of Western Arabia? It may be seen, then, how, following this course, we may advance with secure step towards the discovery of the geological constitution of a country by means of the study of its neighbouring territories; and if the knowledge of the district A thus leads to the contents of B, in its turn, will enable us to reach the constitution of C; and so, as a further step, we need not remain ignorant of the next region, D: but, of course, the verisimilitude of such conjectures must diminish regularly as the distance of the region increases from territories actually explored.

Hitherto we have assumed that *the geography* of the country scrutinized has been accurately ascertained; but even when this is not the case, valuable geological information of a certain amount of probability may be acquired regarding it, by *the accurate study of its analogies of form and contour*. When the windings of our continents and seas are narrowly examined, and the more essential peculiarities of their contours contemplated, it appears that Nature has not wrought after an indefinite number of types or models; but that, on the contrary, her fundamental types are very few, and derived from the action of definite constructive forces on a primary base. The whole of our land and sea, in fact, may be decomposed into a less or greater number of masses, either exhibiting all these fundamental forms, or merely a portion of them. For instance, the Atlantic has sometimes been compared to a mighty river; the Arctic Ocean to a mediterranean sea or huge lake, &c. Frequently the geographer has remarked the triangular character of the southern development of our continents; isles and lakes, seas and continents, have been assimilated as to form, such as Java and Lake Baikal, the Black Sea and Australia, &c. Europe may be divided into squares and parallelograms, by its mountain chains; into ovals by its basins; or even still more abstractly, as M. de Hausluh has pointed out, into grand ovals—the basins separated by triangles formed by the lofty ridges. But without dwelling on speculations so indefinite as this; let us observe, in illustration of our method, what may be inferred regarding two unknown countries—AFRICA and AUSTRALIA;—frankly confessing, that our deductions here have by no means the weight of the preceding cases.

The interior of AFRICA, to the south of the mountains near Lake Tchad, is wholly unknown to the geographer; and the positive geognosy of this great triangle is confined to a few notions concerning its three extremities, and six or eight points on its coasts. Our five grand groups of formations are found at its southern and south-western points; while along the northern base line, and at the north-east extremity, we have recognized only crystalline schists intermingled with an enormous mass of crystalline and igneous rocks in Abyssinia. Navigators have informed us that chains of mountains, some distance inland, bound the two coasts of Southern Africa, that they are elevated and composed of crystalline schists in Congo; whilst all the old narratives of the aborigines and of travellers cause us to suspect a third chain crossing the continent, almost from Gambia. Now, it is of no moment to geologists, whether this chain is very elevated throughout, or, as is more probable, composed of successive terraces rising above each other, and greatly diminishing its apparent altitude. It is enough that it has no transverse cut or valley except that through which the Niger flows towards the Gulf of Benin; and it follows, that the interior of Southern Africa in no wise resembles that of South America: for rivers flowing in other directions would otherwise be found in it: and also, if it contains secondary deposits, at least that it has no vast tertiary basins, the probable theatres of an active and extended commerce. In Africa, we have only one single break in this elevation of the soil—directly across it. Rivers flow from it only at the west, north-east, and east; and at the only points examined, its mountains exhibit crystalline schists and granitoid rocks. Is it not probable, then, that Southern Africa is a great triangle, circumscribed by three chains, exactly like the peninsula of Hindostan by the mountains of Vindhya, the Ghauts, and the chain of Coromandel? The regions, in fact, have the same form, and a very similar potamography: they both enclose very elevated districts, as well as plateaux and terraces; and the chains which bound them appear of corresponding constitution. If in Hindostan, then, the crystalline schists and massive igneous rocks abound at the expense of all other formations, may it not be suspected that this holds likewise in Africa—the more especially since such appears to be the character of all the grand points that terminate the continents of the Southern Hemisphere? The middle of the Indian peninsula, again, being occupied by enormous eruptions of trap and basalt, is it too rash to suppose that igneous masses, not much dissimilar, have formed considerable deposits in some parts of the centre of the elevated African triangle? Whilst in Asia, the peninsula is bounded towards the north by the Himalaya and its parallel chains, is not the tradition probable, that in Africa there is a large upheaval, to the north of which is Sahara, a basin deeper than the Mediterranean, crowned by its Alps?—the chief contrasts being in differences of extent, and the levels of the chains and cavities of the two continents. Finally, analogy tells us that the eastern chain of Africa may be composed of crystalline rocks, mingled with transition formations like the Eastern Ghauts of Hindostan; and the geognostic constitution of the southern part of Africa seems in support of this conjecture. If this great district conceals secondary formations, they will be found on the exterior sides of that triangular fabric, and not in the interior or on the summits of the high chains. As to tertiary deposits, those of marine origin will be on the coasts, or very near them; or if the interior contains any, they will, like those of Hindostan, have formed the basin of fresh-water lakes. The Negro would thus, in all probability, inhabit a triangular platform, bounded by crystalline schistous chains, intermixed with numerous granitoid rocks, with some transition chasms in the south and east, and even a few secondary rocks, especially of a recent epoch, near the south. In the centre we shall find, forming plateaux, basins of fresh water, and an igneous region, probably of a different epoch from that of Abyssinia, or that of the maritime borders of Sahara.

The insular continent of AUSTRALIA having its figure defined, and its coasts in some parts examined; we may also venture to cast its geological horoscope: but its character as an island, and the recent date of its discovery, deprive us of many of the lights which already illumine, however feebly, the soil of Central Africa. If we choose to regard this southern continent as another South America, attaching itself under the sea to Eastern Asia, which in this case would represent the rest of America, it would be easy to complete the picture by the following traits:—Borneo would occupy the place of Yucatan; the volcanic isles of Sunda with Malacca, would represent Mexico and Guatemala; those of the Isawaki would correspond with the great peninsulary of California; the termination of Cambodia with Florida; the Gulf of Carpentaria with the basin of Maracaibo; whilst the small Antilles—the relics, probably, of larger masses—would be reproduced in New Guinea and the neighbouring archipelago. In regard to the shape of Australia, we clearly cannot class it with Africa; its potamography and geology must also be greatly different. It may, on the contrary, without stretch of fancy, be compared with the northern half of South America, including its termination at Tierra del Fuego, but with the middle of that continent removed. The figure of the peninsula beyond the Ganges has likewise a remote similarity to the Australian polygon. Now, on the ground of its shape, and of what we know of the geology of this fifth division of the globe, it may be suspected that its eastern portion, like Brazil and Cochin China, is formed, in great part, of crystalline schistous and transition chains, reaching from north-east to south-west, with large and important secondary deposits on the north-west coast, as well as around the Gulf of Carpentaria—an indentation which, probably, mainly owes its origin to the partial destruction of those latter rocks. In the west and south we should expect great tertiary basins, to whose existence, in a large measure, the striking sinuosity of that part of the continent named the Right of Australia, would be due. Under another view of the subject, Australia might be compared with southern America *reversed*; that is to say, likening the east of Australia with the American coast along the Pacific; and Guayana and Brazil with the western districts of Australia. Without changing on that account our presumed general distribution of the strata, it might then be conjectured that in the interior, an ancient strait of a sea is now occupied, as in America, by tertiary deposits and alluvions, which should appear on the southern and western coasts—including at the south-west point, a schistous, granitoid, and transition island, like Brazil in relation to America. This ancient arm of the sea, or simply this great gulf, stretching in the interior from west to east, might even separate the secondary strata of the north-west coast from the older rocks of the interior; in the low parts, some basins might be found suitable for receiving the waters of this continent: and rivers might, in many cases, be lost in its sandy soil. In neither case are we induced to suppose that this continent contains chains so elevated as our Alps; for certainly there would then be a greater display of igneous matter: can we presume that, with our Alps and the Himalaya, we need expect to find secondary rocks raised to the crests of lofty hills. Besides, the *direction* of the Alpine and chief Asiatic chains do not correspond with the only possible range in Australia, viz., from north-east to south-west; perhaps, from north to south; but not from east to west.—It is necessary now, however, to quit this course of speculation, for our conjectures are increasing in vagueness and uncertainty, and therefore promise little positive fruit.

V.

The exposition of the laws and analogies by whose aid we have endeavoured to execute a first and *exploratory* sketch of the geology of the globe, being now complete, it will be fitting, with the chart before us, to inquire what general views are suggested by its great assemblage of phenomena.

I. The CLASSIFICATION of the Geographer is not, it is manifest, in agreement with the views of the Geologist; who requires to divide the globe into the following primary regions, viz.:—1. ASIA, with its great peninsulas, of which EUROPE, and the States of BARBARY form the *chief*; 2. NORTHERN AMERICA, including Mexico and Guatemala; 3. SOUTH AMERICA; 4. The NEIGHBOURLAND of AFRICA—the whole of this continent north of Sahara, belonging essentially to the grand Asiatico-European quadrilateral; 5. AUSTRALIA, and its isles; 6. The ANTARCTIC REGIONS; 7. OCEANIA.

The first six of these important continental masses are *nearly independent*, having each a few satellites or subservient regions; and they all exhibit enormous nuclei of crystalline schists and massive unstratified rocks, whose magnitude and number are in close relation with the size of the continent whose skeleton they form. In America, and in the group of Europe and Asia, we have two such nuclei, but in Africa only one. In respect of Oceania, geologists are now inclined to view it under a peculiar aspect, directly connecting it with the actual progress of the mightiest changes that have altered the surface of the earth. Within its immense range, we have at once the embryo of new continents, and the relics of immense masses that have disappeared through submergence beneath its waves. According to the remarkable investigations of DARWIN, that long range of coral islands—atolls, or islands engirt by coral reefs—extending from the coasts of New Guinea almost without interruption, towards those of South America, are simply the crests, or fabrics reared on them by the madreporæ, of an immense range of mountains belonging to a continent that during many ages has been *subsiding*. Of the form of that continent we have no intimation, except from the direction of its principal mountain chain; with which, in some measure, it must have conformed. On the confines of this vast region of subsidence, great areas are grouped, within which the process of *elevation* is proceeding;—for instance, the coast of Chile; the Antilles; the volcanic chain or group to which the Sunda Isles belong; the district of Kamtschatka, &c. *Oceania* is thus an existing and impressive evidence, alike of the reality and magnitude of the oscillations which must have affected the Earth's crust or surface; and of whose actions its present or visible forms are the latest result.

Except for the Isthmus of Panama, and the elevation and drying of the former Mediterranean which covered Sahara, these six continents would be everywhere *surrounded by seas*. Previous to the emergence of the African desert, our Mediterranean probably *did* not exist, at least in its present state; and the southern part of Europe was then probably less fragmentary, and connected with its former appendix—the Barbaresque States. During the later upheavals among the Alps, the Sahara probably underwent its last elevation; and the enormous subsidences occurring between these two upheaved regions, produced the basin of the actual Mediterranean, whose accidental forms and relations induced the civilization of our Race to linger around its shores for some thousands of years.

Regarding them in a very general view, and connecting Africa with Europe, and Australia with Asia, it may be said that our existing continents are made up of *three masses, of the form of the Americas*. Around the North Pole, with the exception of the northern promontory of Asia, the land terminates with the seventy-third parallel; from which circle it stretches south, along the American line to 53° south latitude—the African extremity reaching only 35°, while the Asiatic prolongation attains 40°. We shall not venture with M. Boué to discern in these phenomena a probable result of the gradual flattening of the terrestrial spheroid through effect of its rotation—a throwing off, so to speak, of the land towards the equator; but certainly the peculiarity of the arrangement referred to forbids its being regarded as accidental—pointing rather to some general, though obscure cause, in the figure of the solid on which the present continents are placed, and the mode of action or habitual direction of the forces existing within the interior of the globe.

II. The grandest feature of the continental masses is unquestionably those immense MOUNTAIN CHAINS, whose form and position are so closely connected with the earth's past history. Dividing these imposing ranges into two great classes, viz., the chains which stretch along the parallels, and those whose direction agrees with the meridians; we discern, by inspection of the map, that the former class is the more

first principle in mining; with which was soon associated the corresponding law, that fissures differing in direction also differ in age: and when the nature and extent of these fissures are considered, viz., that they are rents through solid strata, often of unfathomed depth, and also of immense length, it seemed to require no unwarrantable boldness to extend the law to every dislocation undergone by the solid crust of the earth. At first regarded with favour as a high probability, this extension has been confirmed in many important instances by almost every geologist who, since Saussure and Pallas, has scrutinized the phenomena of mountains. The subject very early attracted the attention of the veteran Humboldt. Von Buch traced through Germany four distinct systems of parallel chains; and the English Geologists treated under the same view the interesting and complicated ranges connected with Westmoreland.[1] Should the inference be fully confirmed, that all strata elevated simultaneously assume a parallel direction; and—with whatever qualifications—that parallel strata are contemporaneous; it will not be easy to over-estimate the facility with which the Revolutions of the Earth may then be resolved from confusion, and arranged as indices of far-stretching laws. Observe, for instance, the Pyrenees and Apennines. No longer would these two ranges be regarded apart, or even as a twin system—the one, the prolongation of the other; but we should view them as single fissures in a vast zone, of which the extreme boundaries lie probably across the Atlantic, and in Asia; and which bears on its surface, as results of the same pressure from within, chains of various orders and dimensions, from Cape Ortegal in Spain, eastward to the Persian Gulf. Thus also, with the principal chain of the Alps:—its immense peaks and stupendous valleys would not then hold captive the imagination; for it would shrink also into a solitary fissure in a zone still mightier than the former; in whose strain and splitting by the energies from below, we might discern the origin not merely of the huge mountains hemming in the Mediterranean—the Sierra Morena, the Eastern Alps, the Balkan, the vast Atlas; but also of lowly Caucasus crowned by the touchyte cone of Elbrus, the Paropamisus, Hindoo Koosh, and the Himalaya—containing the loftiest peaks of the Earth. Perhaps the illustrative map placed at the right of M. Boué's will show the importance of the principle laid down for examination, more strikingly than even these separate examples. Under its analysis, the confusion of the masses heaped over the countries immediately north of Italy, wholly disappears; and we recognise instead, a mingling of remote and orderly operations;—the mutual interfering and modifying by each other of grand processes, all subject to law, and by whose regulated and appointed march, existing forms have been evolved.

II.

The subject now under notice was first effectively exposed by the illustrious Frenchman Elie de Beaumont; and assuredly one of the most valuable contributions expected towards the history of the formations of the Earth, is the revisal and extension, by that distinguished Geologist, of his early speculations. In the meantime we have subjoined De Beaumont's original abstract as laid down in his letter to Baron Humboldt in 1832; for, through all its inaccuracies, the student will apprehend the spirit and reach of the commanding generalization. The chart accompanying the original memoir, is reproduced at the left hand of our map; and those relations of horizontality and inclination, by which the sedimentary strata fix the epochs of the several upheavals, are so clearly represented by it, that no room is left for misapprehension. The mountains of Europe, with their cognate ranges, appeared to De Beaumont divisible into twelve grand and distinctive systems; arranged as follows:—

I. System of Westmoreland and the Hundsrück.—The first clear definition of this very ancient elevation is due to the researches of Professor Sedgwick in Westmoreland. Its recognised range is also very extensive, as, besides the Westmoreland hills, it comprises the southern range of Scotland, from St. Abb's Head to the Mull of Galloway, the ridges of the Isle of Man, the slate rocks of Anglesea, mountains in North Wales, and Cornwall. The ridges of the Hundsrück, of the Eifel, and others in Nassau, have, notwithstanding their great elevation, been referred to this system; but the probability is, especially with regard to the Hundsrück and the Taunus, that these elevations result from a *long continued* action from below, whose force, as remarked by Professor Sedgwick and Sir R. Murchison, is not yet expended—showing, in the hot springs and bubbling fountains of that region, indications of feeble, and perhaps expiring efforts. These heights, in so far as they belong to the Westmoreland system, must have originated previous to the deposition of the old red sandstone; for the upturned slates pass uniformly under that system: it seems likewise clear that only the *earlier Silurians* were disturbed and displaced by the elevating forces. The system is thus probably the most ancient of which our globe can now furnish any traces; although, as those disturbed Silurians must themselves have been deposited by the ocean as the debris of mountains, we have no ground whatever for regarding even this early dislocation as the first action of interior forces upon the earth's surface. It appears certain, too, that the ranges De Beaumont has included in the group, are but the slenderest fragment of the changes impressed on the globe by the movement in which they originated; for the direction of the upheaved strata, *nearly north-east to south-west*, coincides with the prevailing direction of the ancient strata, although unaccompanied by mountains, in almost every portion of the globe. It is the line along which the old strata of Northern Russia have been dislocated,—the great lakes in that region being *transverse valleys*: Captain Bayfield has noticed similar facts in North America; and Humboldt long ago marked the immense extent of the regions manifesting the presence of this line of force.

II. System of the Belches in the Vosges, and of the Bocage in Calvados.—The late Silurian rocks, which show no trace of the previous dislocation, and which must have been deposited at a subsequent period, manifest, in their turn, the action of a force in the direction east, 15° south, to west, 15° north; and with this disturbance, also prior to the epoch of the old red sandstone, various mountain ranges, diversely placed, are associated. To these, according to De Beaumont's first views, belong part of the Vosges, the hills of the Bocage, in Calvados, in Ireland, and in Devonshire, elevations near Magdeburg, and probably the older part of the Harz. The direction is nearly constant; inclining, however, towards direct east and west.

III. System of the North of England.—From Derby, as far as the frontier of Scotland, a mountain axis intersects the soil of England running almost directly from north to south, or deviating a little towards north-north-west. The critical discussion of this important range is another of Professor Sedgwick's numerous contributions to the higher departments of English geology; and he has distinctly shown, that while the carboniferous system has been upheaved, the time of the action of the force must have preceded the deposition of the lower new red or Permian sandstone. This elevated zone is chiefly remarkable for its immense faults and slips in the mixed strata; by means of which its presence can be traced beyond the sphere of its more mountain ranges. In close connection with it are the rocks which pierce and dislocate the local formations from Shrewsbury as far as Bristol. Nay, that part of the French coast of the Channel, which runs north and south, intimates, in several ways, that it was originally a fault, occurring, during the time of the great North of England elevation.

IV. System of the Netherlands, and of South Wales.—This system of De Beaumont's extends nearly east and west, and may be traced from Aix-la-Chapelle in an unbroken line, as far as the Bay of St. Brides in Pembrokeshire. Its elevation seems to have taken place after the deposition of the lowest member of the new red formation, and before that of the magnesian-conglomerate of Bristol.

V. The Rhenish System.—The investigation of the Rhenish group was one of the many labours of Von Buch. Its chief and most distinct development lies parallel to the Rhine from Basel to Mayence, forming one declivity of the Vosges, on one side of the river, and the Black Forest on the other. The epoch of its elevation lies between the completion of the Vosges sandstones, and the beginning of the formation of the Triassic system, whose three members (Gres Bigarré, Muschel Kalk, and Keuper), spreading around its mountains, represent the shore which the sea washed during a period of rest preceding the commotion. The direction of the Rhenish system is north 5° to 10° east.

VI. System of Morvan, of the Bohemian and Thuringian Forests.—Above the Keuper, the upper member of the Triassic group, lies a series of beds of a remarkable nature, termed in England, for the most part, the Oolite, but in other countries, the Jura limestone, or more properly, the Jura formation. Now, we have a new range of uprisings, close to whose base can be traced the Jura rocks in their first horizontal position; and where the Keuper is dislocated and upheaved for the first time. These mountains stretch uniformly from north-west to south-east; and are found near Avallon and Autun in Central France; on the south-west of Brittany and La Vendée; in the Thuringian Forest, and between Bohemia and Bavaria. An extensive system then, characterized by this new direction, must have been formed in Europe between the ess of the deposition of the Keuper, and of the Luxembourg sandstone.

VII. System of Mont Pilas, of Côte d'Or, and of the Erzgebirge.—Innumerable phenomena testify that in the interval between the two periods of rest, which correspond to the deposition of the Jura formation, and of the green sand and chalk, a sudden and important change in the mode in which strata are laid down, was ushered in by the elevation of a large and widely-spread system of related mountains. The Erzgebirge, the Côte d'Or, the Mont Pilas, and the Cevennes, belong to a closely connected group of elevations running from north to south—west, from the banks of the Elbe to the Channel of Languedoc. In Burgundy, and the other parts of France, throughout the whole extent of these upheavals, the Jura formation is dislocated; and in Saxony, where the Jura rocks are wanting, the strata of the green sand and chalk are spread out horizontally at the base of the mountains. If, then, the French system and the Erzgebirge belong to the same epoch, as might be inferred from identity of direction, the two phenomena determining its place, are manifest; and the absence of the green sand in the one case, and of the Jura limestone in the other, is rendered of less importance by the existence among the valleys of the Jura of horizontal beds, evincing by their petrifactions an undoubted contemporaneity with green sand.

VIII. System of Monte Viso.—The French Alps, and the south-west point of the Jura of Antibes and Nice, as far as Pont d'Ain and Lons le Saulnier, exhibit a series of mountain ridges and dislocations, extending from north-north-west to south-south-east, in which the older members of the cretaceous group are inclined, as well as the Jura rocks. But, lying horizontally over these, we have discovered the upper or newer cretaceous strata; so that the date of the elevation is subsequent to that of the previous system, but before the beginning of the tertiary era. The chief height of this group is the pyramidal mountain of Monte Viso.

IX. The System of the Pyrenees.—A glance at a good special map of France and Spain, readily shows that the Pyrenees constitute a system peculiar and almost isolated; and separated by their predominating direction from the mountain systems of the interior of France, as well as from the transverse chains of Spain and Portugal. The line of their elevation is from west-north-west to east-south-east; in Provence, we again find it; but in Europe, the other principal development of it, is among the Apennines. The most extended portion of this complex group is clearly identifiable with the Pyrenean system; the chain, viz., which separates Modena from Florence, that between Bari and Otranto, and the two volcanic ranges, one of which passes from the vicinity of Rome to Benevento, and the other through the Ponza Islands, Palmarola and Ischia. Traces of correlation again appear among the Julian Alps, some parts of the mountains of Croatia, Dalmatia, Bosnia, and Greece; in a portion of the Carpathian range, and in a few districts of Northern Germany, among which most especially be ranked the northern shoulder of the Harz. Sedgwick and Murchison are inclined to attribute to the Pyrenean epoch a part of the Eastern Alps. M. De Beaumont included in this great group the Alleghanies of North America, and their place is preserved on the map as represented by him. But the fact of identity of direction applies only to a small part of these mountains; and there is no doubt that, while they have been subjected to many changes, the main action of the forces that upheaved the chain preceded the deposition of the new red sandstone.

The geological period of the rise of the Pyrenees, is included between the close of the cretaceous strata, and the origination of the tertiary beds:—some deposits even that have been said to lie between the chalk and the tertiaries, are dislocated by this chain.

X. The System of Corsica and Sardinia.—We enter the latest portion of the geological history of the earth—the period of the dislocation of the tertiary strata. De Beaumont divided these beds into two principal classes—the older and later—the former, including the plastic clay, the gypsum formation, and the upper sea marl; and the other, containing all the newer tertiaries down to alluvium. Now, it is the boundary between these two series which seems to correspond with the epoch of the elevation of the mountain system at present referred to, which rose in the direction north to south—the newer tertiaries being undisturbed, and the older inclined in every instance belonging to the group. The group is an extensive one, and has been minutely examined in Europe. Those belong to it the east and west of the Côte d'Or, in Auvergne, Velay, Languedoc, near Clermont, lie the extinct volcanic cones of the Monts Dome; and in the broad furrows separating the chains, the fresh-water formations of Limagne, Auvergne, &c. Here, also, we must class the valley of the Rhone, the chief *mountains of Corsica and Sardinia*, prolonged with many interruptions into North Germany; likewise many chains of the Apennines; others in Istria; the metallic veins of Hungary; the chain rising in the Island of Sumia, and stretching parallel to the meridian, on the one hand to Macedonia and Thessaly, and on the other to Albania. Corresponding elevations are found on the coast of the Morea, near Napoli, and in the west of Crete; and the same direction is again evinced by the coast of Syria, and the Chain of Lebanon. The conclusions from more distinct districts, which De Beaumont has, as is seen on our copy of his map, included the Oural range in this system; but it has been clearly made out by Sir Roderick Murchison in his recent publication, that the forces to which a large portion of the upheaval and dislocation of this chain are attributable, must have acted with great intensity towards the close of the *carboniferous epoch*; and, therefore, that the Oural range in thus far belongs to system III.[2] The discrepancy, in this case, as well as the one previously noticed, referring to the Alleghanies, shows the amount of hesitation with which general conclusions regarding unexplored mountain systems ought still to be received, and, at the same time, forcibly demands attention to a remarkable fact which the concluding portion of our essay will further elucidate, viz., the recurrence and apparent *periodicity* of the action of these central forces *along the same direction*. For instance, among the systems we have examined, we have three instances of such a recurrence; twice has the upheaving force acted in the direction of north-east and south-west, producing at one epoch the system of Westmoreland, and at another the system of Mont Pilas, Côte d'Or, and the Erzgebirge; twice in the direction of west-north-west to east-south-east, producing first the systems of Belches and the Bocage; and, secondly, the Pyreneo-Apennine chains; and, finally, twice from north to south, upheaving at the earlier epoch the system of the north of England, and again that of Corsica and Sardinia. A greater number of the erroneous conclusions regarding the age of mountain chains have sprung from the want of due means of discriminating among successive shocks.

XI. The System of the Western Alps.—This great system, involving, near its intersection with the other Alpine chains, the most broken ground, and the loftiest peaks of Europe, has been closely examined in all its important windings by our most distinguished geologists. So far from being a simple or single range, as commonly supposed, *this immense accumulation of mountains* springs from the crossing of many systems, independent of each other, in age as well as direction. Through almost their whole extent, and particularly in their eastern part, we easily recognise traces of many smaller ranges parallel to the Pyrenees, which, like them, were elevated before the deposition of the tertiary strata; but all such comparatively old dislocations of the ground are, for the most part, effaced by more recent ones. Passing from these phenomena, we discern, in the neighbourhood of Mont Blanc, a great bending of the leading chain, so great, indeed, that the range which comes from Anzeis, in the direction of east to north-east, turns suddenly round and stretches towards Italy along the line south-south-west. Now if this were the actual bending of a single chain, the strata would turn round by degrees, and gradually pass from the direction of the first into that of the second system; but the phenomena, on the other hand, exhibit all the appearances of a violent intermixture and confusion, which renders the supposition inadmissible. A similar feature, in the Swiss Alps, compels us to consider the Western Alps, from Monte Rosa through Savoy and Dauphiny, to be one system stretching from north-north-east to south-south-west, or more accurately, from north 26° east to south 26° west, with a constancy that long ago attracted the notice of Saussure. Now, in the interior of this system, the chain can be more than the chalk can be shown to have existed after the deposition of the chalk, the region of the Western Alps had already become dry land, and even hilly—the revolutions of the Pyrenees, and of Monte Viso having been felt there; but at the edges, and at both ends of the disturbed country, dislocations and elevations belonging to them penetrate and affect the newest tertiary strata, so that the rise of the mountain chains must have taken place after the deposition of the latest tertiary formations of those regions. Beds of shell molasse are found at the hill of Superga near Turin, highly inclined, as well as at the west declivity of the granite mountains at Chartreuse near Grenoble. This latter fact is very remarkable, for the same beds that are there nearly vertical, are found in a horizontal position even at the base of the granite mountains of Bauges, which form the banks of the Rhone from Lyon to St. Vallier. How different the ages of these neighbouring rocks—the hills at Forez, and the ridges of the Alps which there towards east-south-east, bend so majestically the Rhone! De Beaumont, it will be observed, includes in this group the Scandinavian Alps; but among these huge masses, the older Silurian groups only have been elevated; and their direction also connects them distinctly with system I.

XII. The Principal Chain of the Alps.—On narrowly surveying the regions in and around Switzerland, we discern a number of ridges in the south of France—the St. Baume, St. Victoire, Luberon,

[1] These eminent men, have, for the most part, connected their investigations with the doctrine of the internal fluidity of the earth, and the action and reaction between this incandescent mass and a solid crust; but the theory of the subject, even in this point of view, stands greatly in need of a more extended and inner portion of the globe to ascertain its temperature—the whole of each shell being isothermal.

[2] The following letter to Humboldt, contains a notice of De Beaumont's later views concerning this chain of mountains:—

"I am of opinion that the Oural chain, notwithstanding its generally rectilineal character, includes, like most ranges of mountains, the crossings of several directions belonging to dislocations of different ages. My first endeavour at classification took notice chiefly of the stratigraphic and orographic peculiarities of the Oural, which, to the neighbourhood of the Tagonai, of the Iaroua, and the Iremel, and in the higher valleys of the rivers Ai and Biela, stretch towards north 25° east, parallel to a line from Ekaterinburg towards the confluence of the rivers Oural and Ilek. I was led to this by the parallelism of this line to the meridian of Cursica." (De Beaumont and M. Boué, it will be observed, are at issue as to the mode in which the direction of corresponding chains should be reckoned.) "Since then, Professor Sedgwick has shown that the *system of the north of England*, much more ancient than that of the Islands of Corsica and Sardinia, is almost parallel to it. It hence results that the consideration of their *directions* allows us to refer in this system the stratifications of the mountains near the Tagonai; and this new classification sufficiently harmonizes with the observations of M.M. Murchison, Verneuil, and Keyserling, which indicate in this part of the Oural, numerous dislocations between the carboniferous period and that of the Permian system, even as the dislocations of the system of the north of England took place between the carboniferous period and that of the new red sandstone. The direction now mentioned is quite indifferent from the general direction of the crest of the Oural, which, in the almost meridional part of the mountains, is more inclined to the east, and in the latitude of Catharinenburg, it has not fled its exact parallel among the European systems. The Oural, as M.M. Humboldt and Rose long ago informed us, presents traces of an extremely recent upheaval. Now, it would appear the most recent of systems of dislocation affecting the European continent, is that which M.M. Robbye and Virlet have designated in the Morea, *the System of Taygetus*—a system of which they have found several unexplored traces in Italy. The direction of this system transported to the Oural, would run about north-north-east—parallel to a line from Perm to Orenbik. This direction is almost parallel to the meridional line of the Permian beds, which M.M. Murchison, Verneuil, and Keyserling, place at Solmanof to the north-east of Orenbourg. Is it then on the prolongation of this line that the most modern deposits of the Oural have been upheaved? On this I do not venture to decide."

We have spoken more than once, incidentally, of those recent labours of *Sir* R. Murchison; but it were wrong to deny ourselves the pleasure of stating thus formally, that, whether looking to the amount of enterprise whose toils and magnificence they record; the extensive and liberal views which pervade them; the singular freedom from theorizing to hypothesis with which their inquiries have been conducted; or the value of their manifold positive results; they appear in this line, the most important additions to geological and geographical science since the publication of those works with which Humboldt himself was personally associated.

later even than the tertiary epoch—one basin dependent on the Caspian, and another annexed to the Indian Sea. In another district of the continent, large portions of the isles of Sunda, the Philippines, Borneo, New Guinea, and Australia were at this period under the waters; and many volcanic peaks now existing, belonging to great areas of elevation, had not yet risen above the surface of the Indian or Malay Seas. Turning to the map of America, we discern evidence of changes equally singular and extensive. The Gulf of Mexico then penetrated deep into Mexico, Florida, the lower basin of the Mississippi, and also into the basins of the northern rivers of South America. It washed the southern extremity of the Alleghanies, as well as the feet of the Ozark Mountains, and the Mexican and Columbian platforms. Further north, a great interior ocean overspread part of this continent—comprehending the highest Mississippi, and the great Lakes. The Gulf of Mexico already contained a few islands composed of old formations—probably of much larger size than those whose shores it now washes; but its volcanic isles sprang into existence subsequently,—during that series of subsidences and elevations, of *accompaniments* of the chains along the ancient shore of South America, which drove the sea from the Ozark Mountains and the Alleghanies, and fixed its limits farther south. The northern part of the continent had three islands,—the basin of the St. Lawrence separating the district of the Alleghanies, from dry land on the banks of Hudson Bay, and perhaps bending round to the Icy Sea. The platform of Mexico and Guatemala, formed an appendix of the long isle of the Rocky Mountains; and the Ozark Chain advanced into the waters. The volcanoes of continental America as we see them now, were contemporaneous with the formation of the Mexican and Mediterranean basins. In South America, we discern abundant proof, that, at the tertiary epoch, the Atlantic covered the great strait between Brazil, the Andes, and Central Guayana, as well as between the Parima and the chain beyond the Orinoco; whence, the mingling of the tributaries of this river and the Amazon, as well as the mode of the division of the waters between certain affluents of the La Plata and the Amazon. South America was then composed of three great islands; for the Isthmus of Panama did not exist.

2. The distribution of the oceans, during the SECONDARY EPOCH, cannot, indeed, be so definitely or surely discerned; but enough is clear to reveal a condition of things still more remote in character, from what is in existence now. The tertiary seas, whose extent has been described, were, during this older period, in close and free communication with each other; for the elevation of the secondary rocks, especially in the old continent, tending to narrow all their shallow channels, diminished the number of their points of contact, and still more—their extent. The formation and upheaval of all the rocks of this group evolved this result; but perhaps their operation is most easily seen in the case of the jurassic and the cretaceous beds. The lower members of the secondary group defined the contours of many basins in Central Europe—as the banks, for instance, of the Rhine; between the Harz, the Erzgebirge, and the Thuringian forest; in England, Poland, Russia, &c. They also separated the great Siberian basin, from the seas of Europe; and probably diminished the magnitude of the Chinese inland seas: Humboldt found them in the valley of the Orinoco, and Schomburgk in the interior of the crystalline district of Guayana. By the *jurassic* formation, on the other hand, distinct walls of separation were established in France, Switzerland, in the south-west of Germany, in Northern Hungary, Spain, and the north of Africa; and new shapes were imposed on the basins of Siberia, China, and Central Asia. Then emerged the *cretaceous* masses, completing everywhere the contours of the tertiary basins, particularly in the three south European peninsulas; at the same time, isolating Sahara from the Mediterranean, forming boundaries to Arabia, Mesopotamia, and Southern Persia, the coast of Tranquebar, the centre and north-east of Asia, perhaps China and Borneo, as well as Australia. They are likewise found on the two slopes of the Alleghanies, on the south-east slope of the Rocky Mountains, in several parts of Mexico and Columbia, and among the Andes of Peru and Chile.

3. Stretching the eye yet farther into the past, traces of the condition of our continents during the TRANSITION EPOCH, although extremely faint, nevertheless appear. In *America*, six islands had arisen above the surface of the ocean. In *Africa*, a continent seems to have existed—or perhaps three or four large islands, viz., the three chains to the south, and the embryo of the Atlas of Morocco. In *Asia*, from three to five islands might be counted. Transition deposits had separated the north of Europe from its neighbouring continent, and marked out, on one side, the first contours of the basins of Australia, Hindostan, China, and Siberia; and on the other, those of Russia, Scandinavia, Central Europe, the British Isles, France, and Spain. Europe as a whole, must have exhibited ten or eleven peaks or primitive islands, above the surface of those early oceans.

If one could regard these few hints, as effecting a reconstruction of the continental systems of the Ancient World,—then, with much accuracy, might be deduced, the position and relations of the grand seas, and an outline of the system of currents arising in their interchange of waters. To discern this with distinctness, would, doubtless, enable us still farther to raise the veil from before the past; for the all-important action of such currents in the distribution of stratified rocks, might furnish a key to the problem of the place and extent of most of these great formations. But did we assume that those islands constituted the mass and defined the form of the continents of previous epochs, we should forget the weighty truth, that the Earth's crust is not merely subjected to a slow process of *upheaval*, but is in perpetual OSCILLATION,—that along with the appearance of every new elevation, there may have been immense submergences, carrying to the bottom of an ocean that will never be visited, extensive fabrics of former dry land. In the Pacific, peaks and islands are at present emerging, and perhaps are the first nuclei of the continents which, in future eras, shall adorn that expanse of waters; but if, before these periods revolve, Asia has sunk, and given place to a sea as unbroken as that which now rolls over the subsiding lands of ancient Oceania, the Geologist who shall then *trace* the slow rise of the regions at present emerging, will yet succeed in no wise, in reconstructing the phenomena that now exist. Over the grand and ultimate questions here indicated, there rests a deep, and apparently a lasting mystery. The fluviatile deposits of the Wealden, or the fresh-water masses of the London clay, may inform us that, at different and far divided epochs, regions must have been connected even with our own islands, of a magnitude that sufficed to feed systems of rivers, as imposing as the Ganges; but the constitution and form of these regions, their influence on the structure of British strata, the impress left by their existence and disappearance on those fragments of the past—the flora and fauna of our islands; such points must remain subjects, at best, for uncertain deduction and conjecture,[1] unless, indeed, we can suppose that our Race and its sciences shall survive, until, in the course of terrestrial mutations, the floor of the ocean is raised once more into dry land—exposing its now hidden contents to examination.

B.

THE ELEVATION OF MOUNTAINS, AND THE CONTEMPORANEITY OF PARALLEL CHAINS.

1.

The doctrine regarding the relationship of parallel mountain chains, on which a part of the foregoing dissertation is dependent, is probably the most definite geogenic conclusion, of the class next to the ultimate, to which Science, in its present state, points with any degree of certainty or firmness. We shall therefore look more closely at its two fundamental propositions.

1. The relation, in point of age, of every mountain chain, to the stratified rocks around it, is established by phenomena whose significance cannot be misunderstood. Overlooking the small exceptional cases whose extent and limits have been well arranged by Sir Henry de la Beche, it may be received as a fact of universal application, that all deposited strata were first laid down *horizontally*; and, therefore, that the existence of a stratified mass, in an inclined position, is an emphatic mark of the operation in that locality of disturbing and dislocating agencies. Now, since every range of mountains is, without exception, accompanied by neighbouring rocks originating in the process of deposition, which are yet highly inclined—sometimes lying almost perpendicularly, and often even *overturned*; Geologists have connected these evidences of convulsion with the Force which elevated the chain; and thus, in the age *of the newest upturned stratum*, we recognise a *date posterior* to which the appearance of these mountains must be placed, in the arranged chronology of our planet. But on examining the associated phenomena more closely, strata are generally met with—posterior also to those upturned beds—which have not partaken, at least to its entire extent, of the convulsion that has shattered the previous ones;—strata in every case *unconformable* with the masses lying on the flanks of the mountains, and very frequently stretching, in their original and undisturbed horizontality, to the very base of the chain; as if they were depositions from seas or lakes, of which that chain once formed the shore. Now, as these phenomena indicate that certain great formations, united to the upturned rocks in a continuous series, have not been affected by any revolution since the period of their origin; we infer that the crystalline masses must have been thrust into being *prior* to the deposition of the oldest of the horizontal strata. The stratifications associated with the chains, establish, therefore, *two grand limiting dates*, between which the mountain range must have been elevated; and as geology has succeeded in tracing the equivalents of most stratified masses over the whole earth—so that on meeting with a stratified rock in one country, we can fix, without much hesitation on its contemporary in another—it follows that the divisions of our globe's annals may be deciphered, and those eras of revolution separately discerned, of which our mountain chains are the suitable and impressive memorials.

The epoch of the convulsion comprised between two such geological epochs, has always a definiteness as perfect as can be hoped for, when the inquirer deals with operations not measurable by recognised and familiar units of time: nor is there reason to believe that it is ever prolonged, so as to become indistinct. It is frequently found, indeed, that the transition from the disturbed to the undisturbed strata, is not accomplished by one single step or act: for instance, if the beds of deposition, A, B, C, and D, are associated with the central chain, we sometimes find the first three inclined, though at different angles, or lying unconformably with each other; so that we pass from the highly disturbed mass A, through the less disturbed series B, and again through the still less disturbed series C, before we reach the system D, which shows by its horizontality that its position has undergone no change. But it by no means follows that an epoch of revolution endured in that portion of the globe from the close of the deposition of the strata A to the beginning of the formation of the system D: the right conclusion being, that within that period there were *three successive upheavals* in the same locality—one between the completion of A and the beginning of B; another between the completion of B and the beginning of C; and the third between the completion of C and the beginning of D—each of them precise and definite in itself, and resembling in all its attributes any solitary convulsion. In the region in question, the interior forces have simply acted thrice than once; while to other districts they have communicated only one single shock, and then shifted for an outlet to some other part of the surface of the earth: but in all cases, the action seems to have been precise, comparatively sudden, and of brief duration; for it simply fills up the interval between the deposition of two succeeding formations, during which, no intermediate series of strata appeared. The enormous upheavals of the carboniferous system, may be taken as an adequate illustration of the whole. The extent of dislocation of these vast beds, having a closer bearing on our conveniences, has naturally arrested a general attention; and therefore it must have been remarked, that although their massive limestones stand up almost vertically, and the coal strata, large or small, are twisted into every zigzag and unaccountable contortion, not a trace of this confusion, which has affected the entire of the system—involving its very last seam or layer in its changes—has passed, in many extensive districts, beyond the superior limit of the carboniferous masses, or affected the magnesian limestone or other member of the Permian group which so often lies horizontally on the convulsed older rocks. It ought not to be overlooked, that in judging of such actions from their apparent results, we discern, however gigantic these are, only a fragment or relic of the reality. The twisted strata remain, and also the upheaved granitic mountains; but effects which, though minor, would, had we desired them, have impressed us much more deeply with the vastness and violence of the commotion,—have vanished wholly, or are to be rescued from oblivion, only as Mr. Ramsay has reconstructed those immense secondary ranges of South Wales, out of the debris strewn through the valleys of the Menddp, by the waters that destroyed them. Neither may it be supposed that catastrophal actions are at variance with the character of Nature as she works around us. In respect of this peculiar force, indeed, we seem to occupy an era of comparative quiescence: but the Vesuvius whose unexpected paroxysm destroyed Pompeii and Herculaneum, was the same mountain on whose flanks villas had been built, and where hamlets and cities increased unchecked, during centuries of a previous and seemingly permanent repose.

II. The means of ascertaining the age of a mountain chain are thus simple and indisputable; and the epoch to which it is referred is sufficiently limited or determinate: but unless each range on the globe's surface were separately examined, we could form, by the considerations now explained, no general theory or conception of the course of the great changes to which it has been subject. At this point, however, we are aided to an unexpected extent by the important principle of the *contemporaneity of parallel chains*. This principle has long been known to miners; it was, indeed, one of the earliest discoveries of the school of Freyberg. After much experience, considered and discussed with his singular acuteness, WERNER reached the conclusion, that in the same district, all the lodes of a mine of the same nature arise in *parallel fissures* opened at the same time, and probably filled with metal, also simultaneously, at some subsequent period. The contemporaneity of parallel fissures and faults became, in fact, a

[1] It seems almost an error to speak of such deduction as uncertain, after the very excellent essay by Professor EDWARD FORBES, entitled, "*On connection between the Existing Fauna and Flora of the British Isles, and the Geological Changes which have affected their Area, especially during the Epoch of the Northern Drift.*"

Ventoux, and Montagne du Poet; and more northerly, the ridge containing Mont Pilatus, and five or six smaller ones, which, notwithstanding their disproportion, are yet all conformable with each other, and the great Alpine chain stretching towards the east through Austria, on account of their strict parallelism. The close proximity of the ranges would of itself induce us to consider this parallelism as strong ground for concluding that their origins were simultaneous, and that they constitute one fissure system; but their intimate relationship is farther and satisfactorily established by the position of the two main groups in reference to a general elevation of the soil of an important part of France. This elevation, lying exactly in the prolongation of the great Alpine chain, stretches across Europe from Hungary as far as Auvergne, and is connected with the most remarkable anomalies that geodetic measurements and experiments with the pendulum have yet unveiled in the constitution of the interior of our planet. Now, the group of Mont Pilatus lies on one declivity of the elevation which extends as far as Dijon, and the group of Pouvenes lies on the other that descends to the shores of the Mediterranean. But, on both these declivities, the beds of lakes wherein mud or soil was deposited after the tertiary era, have been turned out of their horizontality; and on the top of this inclined alluvium, the more recent alluvium laid down by many streams, still rests, as it was formed, in horizontal layers. The epoch, then, of this, the latest grand paroxysm to which Europe has been subjected, is definitively and surely fixed; and its extension to the immense ranges of the Himalaya, on which Beaumont ventured on the ground of analogy of direction, has received a striking and abundant confirmation by the brilliant researches of our countrymen, on the Sewalik, and other pendants of the spine of Asia.

Granting the uncertainty of our knowledge of many details necessary to perfect this speculation, how imposing the representation it summons up of the past history of our Globe! Standing on the modern peaks of the Andes, huge ranges of mountains group around us, scattered widely over the earth, as the product of the last grand revolution; behind these—as stars of the second magnitude lie behind those of the first—another group seems to arise, whose origin carries us a stage farther among those profound durations; there—deeper still into the past—a third multitude is recognised, although perhaps more faintly; and so are we led backwards, until the annals of our small planet merge into that darkness which obscures all beginnings! The intervals between these land-marks no imagination can conceive; nor even Reason find expression for them. On De Beaumont's map, how evanescent the space between the rising of the Oolite at Cote d'Or, and the upheaval of the chalk by the Pyrenees; but yet, within that small passage of the earth's revolutions, were crowded, the apparition of continents drained by the rivers of the Wealden; the life and death of species, whose hold on the earth's surface, might have seemed a possession as lasting as that enjoyed by the creatures at present inhabiting it; submergence of the whole under the waters; the development of the agencies which elaborated the chalk; and finally, the upheaval of that rock and its equivalents during the rising of the Pyrenean chain!

III.

The gigantic phenomena whose relations we have discussed, doubtless do not stand out singly or unassociated, among telluric changes. Capricious though they seem, they unquestionably have proceeded according to some fixed and vast order; regarding which, we shall perhaps receive our earliest hints, from correlations discerned between those systems of mountains, and other physical attributes of the Globe. Now, intimations are reaching us from diverse sources, that the internal condition of the earth, as to action or repose, may be closely connected with the varying play of the magnetic or electric forces: nay, it is not improbable, that a far more thorough metamorphism than has yet been suspected to exist—a metamorphism involving the shifting of huge masses as its accompaniment—results from the persevering influence of these potent agencies. With M. Neckar de Saussure, we are not, therefore, disinclined to recognise a possible connection between the disposition of existing mountain chains, and *the distribution of the magnetic forces over the globe*. It has been conceived by this able Inquirer, that there is a marked concordance between the *prevailing direction of the stratified masses, and the bendings of the curves of equal magnetic intensity*. M. Neckar does not speculate on the significance of this relationship—not venturing to discriminate which of the two, is *cause*, and which *effect*: nor are the irregularities of the magnetic curves sufficiently ascertained to justify our attempt to follow the relationship through confused districts, where, as in the region north of Italy, numerous zones intermingle, and the order of the upheaving forces must be disentangled by the separation of many distinct chains. Considering them, however, with the forbearance due to avowed approximations in regard of a new and extensive scheme of relations, the following facts, which are easily traced on a map of the lines of magnetic intensity, seem possessed of no trifling interest.

1. On the west coast of Europe, the direction of these curves is chiefly from south-west to north-east, which has long been remarked as the prevailing direction of stratification in these regions. In Scotland especially, the curve almost coincides with the Grampian chain; and, as it becomes less northerly before reaching Portugal and Spain, we find it here also in singular accordance with the Sierras, which crown the *elevated* plateaux of that peninsula. Before entering Sweden, the line of intensity 1·4 tends to recurve in order to sweep down the plains of Russia in a direction towards the south-east; but as the line 1·5 passes northward *parallelly to the Norwegian coast* previous to recurving in the Arctic Ocean, there is little doubt that an intermediate line pursuing a course through the Scandinavian Alps will be found to take that direction. The magnetic curves through European Russia does not diverge greatly from the direction of the stratifications of its immense plains; but on reaching the Oural the concordance is complete; the magnetic line of 1·55 passing there from north to south.

2. In the south-west of Europe, the elevated zone of Spain lies in the direction of isodynamic curves; but its fracture by the Pyrenees—also a geological anomaly—indicates an exception to the law, or at all events, an irregularity in the curve in that locality, which is not yet detected. Farther east we reach the Alps; and notwithstanding the broken and complex nature of these territories, we are struck by a most surprising *consilience*—the magnetic line following, with much precision, the break in the great Alpine chains. As explained above, the interference or intersection of two upheavals causes this important range of mountains to seem to alter its direction, from south-west and north-east to another almost easterly; and in the intermediate neighbourhood of this break, the magnetic curve bends similarly, sweeping through Asia, along the peaks of the Caucasus, Taurus, the Parapamisus, the Himalaya, and the Chinese ranges, when it again points northerly, following the Yblanoi chain towards Behring Strait.

3. In the interior of Africa, of course, no curves have been traced: but on connecting observations obtained near the coasts, the isodynamic curves appear to coincide with the direction of the still hypothetical chain on the south of Sahara; and with the lofty sea coast ridge, which incurves the towering peaks of Abyssinia with the Table Mountain. It is likely, also, that there is a node, or rebending of these lines, within that vast sinuosity of which the Gulf of Guinea is a part.

4. After Europe, North America is best known to geologists; and throughout its wide extent, the direction of the stratified masses corresponds with the isodynamic curves. On the eastern surface of the United States, we recognise the direction of south-west to north-east, as characteristic of both phenomena; and in the regions near the Pacific, the magnetic curve lies along the line north-north-west to south-south-east, which is the course of the Rocky Mountains. In Mexico, Humboldt found the stratified beds lying parallel to the Cordillera of Anahuac, or from north-west to south-east—also the direction of the magnetic curve passing through them; and a similar accordance is discernible near the littoral chain of Venezuela; in the countries between the flats of the Orinoco, and the basin of the Rio Negro, and the Amazon. So far as is yet known, the Andes of South America are singular exceptions to the rule, for they are crossed by curves of value from 1·0 to 1·5; but to counterbalance this, lines appear to stretch downwards from the southernmost promontories of America and Asia, straight towards those massive headlands within the Antarctic regions, which our adventurous Countryman has discerned as our first intimation of a continent hidden, until now, within the barriers of Polar ice.

IV.

It is a still remoter inquiry, whether order is discernible in regard of the successive upheavings of these mountain zones—that is, why the elevation of one particular zone, succeeds that of another? Indications on such a point should perhaps appear in the *successive directions* along which the ridges have been upraised; but the twelve systems of De Beaumont only inform us, that along the directions north and south, north-east and south-west, and east and west, upheavals have otherwise occurred; so that these, in so far as we have yet deciphered, are the favourite *lines of Force* in this scheme of telluric agency. Until the surface of the globe is far more minutely scrutinized, we shall speculate, indeed, concerning such subjects, on the ground of a very fragmentary knowledge. There may be elevations yet undiscerned belonging to the most ancient periods, whose traces are not wholly obliterated; and others will doubtless be recognised, dating among later times, which, although involving actions of high energy, were undistinguished by an accompanying rise of mountains. But it should never be forgotten, that in this region of inquiry, as in all others connected with geological History in its largest sense, we shall always be met by that irremovable obstacle to complete knowledge—the fact that so much that we desire to know is concealed by the waters of the Ocean.

C.

THEORETICAL CONSIDERATIONS RELATING TO THE ELEVATION OF MOUNTAINS.

The laws concerning the relations between the parallelism and contemporaneity of Mountain chains, possess, as presented above, only the certainty and extension generally due to *empirical laws*, by which effects are grouped together, without reference to their causes. The subject, however, in its ultimate and only satisfactory state, ought to exhibit how the remarkable effects in question flow from fixed and probably simple principles; and thus alone shall we be able to estimate the extent and bearing of the relations we have discovered, and discern our way through their apparent failures and ambiguities. As hinted in several parts of the previous memoir, attempts have not been wanting to elucidate the laws in question by reference to the supposed refrigeration of the globe; but our best lights here are only dim and unsatisfactory.

The true dynamics of geology owe their foundation to Mr. Hopkins of Cambridge. Avoiding all ultimate theories, he rests simply on the fact, that upheavals do take place, not of chains of mountains merely, but, as investigation demonstrates, of vast zones, of which these ranges are the mere accidents; and the question is, Whether by aid of the common laws of Force, we may not deduce some general features necessarily characterizing all such dislocations of the earth's crust? Mr. Hopkins' inquiry—now extended over several highly instructive memoirs—has three special divisions.

I. The simplest case of elevation is that in which the upheaving force is limited to a small area—say to a point on the earth's surface—its intensity diminishing according to distance from that point. The upheaval under such circumstances will manifestly be confined to a limited circular region, and must result in what is now well known as a *crater of elevation*. The splits or fissures of the upraised strata will probably be confined to a single system—a system, viz., along radii from the central point; or there may exist separately or conjoined with the former, another system dividing the distended soil into concentric rings. The phenomena attending such upheavals had been fully discussed previous to the investigations of Mr. Hopkins, by Elie de Beaumont and Dufrenoy—perhaps with an aim at too high numerical precision—in their interesting memoirs on the volcanoes of Central France; where every attainable elucidation is thrown on the phenomena of circular elevations. It has been already remarked that this species of dislocation seems to have prevailed among the older epochs of the history of the earth; and certainly it has affected most abundantly the existing surface of our satellite.

II. The upheaving force, however, instead of being confined within a small district, may be diffused below a large tract or zone; and the simplest mode of considering its operation in this case, is to neglect the shape of that zone, unless in regard of its two dimensions, length and breadth. Now, if such a zone be elevated, it must, during the whole course of its upheaval, be *stretched*, or subjected to *tensions*, which incline to tear or split it; and a little consideration will show, that (as results from Mr. Hopkins' Geometry) these tensions must reach their *maxima* in two directions; one set inducing the zone to split in the direction of its length, and another acting at right angles to these, and tending to produce fissures along the zone's breadth. Without going farther then, we obtain an insight into the phenomena of *transverse valleys* uniformly characterizing every mountain chain; and the reason is seen why mineral veins are generally found associated in two systems, at right angles to each other. A very effective attempt is made by Sir R. Murchison, in his recent Memoir on Scandinavia, to explain the broken outlines of these northern regions by this prolific principle.

But if, in either of those directions, the zone yields in more than one place, it must do *so along parallel lines*. The direction of the *length* of the zone being that of the *maximum* of one set of tensions; it is plain, that whether the zone splits, in obedience to these tensions, in one place or many, the fissures must observe *that direction*, and no other; and as the zone must here be supposed of uniform constitution, it is much more likely that several cracks will take place, than merely a single one. Nor can there be a doubt that these parallel fissures must occur *at the same moment of time*; for, on the occurrence of one crack by itself, the tension would clearly be relieved; and the only result of a farther upheaval would be the mere widening of the first crack, which is now a *line of weakness*. Hence, then, the frequency of the phenomenon of parallel veins, and hence their necessary contemporaneity. There is no difficulty in verifying these deductions, in all the aspects and relations of mineral veins, faults,[1] &c.; and the same physical principles, therefore, overrule that grand series of dislocations treated by Elie de Beaumont. It appears, then, that the contemporaneity of parallel chains crowning the same zone of upheaval, must be taken as absolute and undeniable; but unfortunately there are two considerations which prevent our absolute *application* of the principle; and in which those difficulties originate that are so emphatically indicated in De Beaumont's scheme of Systems, by the existence of separate groups, of widely different ages, but with corresponding directions. The first source of ambiguity is in the effect of successive shocks of elevation undergone by the same zone; for though these can create no new fissure, but would simply further elevate the mountain chains resting over the old ones; they may make, even at a late period fissures *belonging to the oldest date, and to the first time*. Mr. Hopkins clearly demonstrates that the cracking of every zone, begins on its *upper surface*, and proceeds downwards; and as it is perfectly conceivable that the first shock may not have completed the split in many cases, or caused it reach the surface, it is quite consistent with theory, that subsequent shocks, while farther elevating the masses protruded through many splits, may suffice to *complete others*, and rear over them a mountain range, not referable, in so far as dislocations of the neighbouring strata intimate, to the epoch of the first disturbance. Mr. Darwin also inquires what might be the probable effect in strengthening an old fissure, of long intervals of rest, during which the injected rock had intertwined itself with the other beds around it, and formed with them one consolidated mass? "Would not," he asks, "the force in such case yield more readily on a subsequent shock, than it was able to rend asunder a solidified rocks, such as granite and porphyry?" But, besides the law only holds in the case of mountain ranges *belonging to the same zone;* and there seems no reason to believe, considering the crust of the earth's surface, and the frequency of these oscillations, that *different zones*, with major axes corresponding in direction, may not have been acted on at different epochs. For instance, with regard to that immense area now undergoing subsidence in the coralline regions of the Pacific, is it not probable that its major axis corresponds in direction with the Eastern Alps and Himalaya; and, therefore, that such also will be the direction of its system of dislocations? It is far from improbable that the groups in De Beaumont's scheme, which correspond in direction, but differ in age, demand such a solution; and that this is the information they give us regarding the History of the Earth. The all-powerful exceptions to simple and enlarged truths, such ambiguities, while checking the universality of our application of general laws, do not invalidate the laws themselves, but only inform us better of the circumstances within which they have operated.

III. Mr. Hopkins next surveyed a case in which the resulting phenomena might be supposed modified by the shape of the upraised surface; and probably his application of general principle to the specialities of the Weadden, is as complete a triumph as any inquiry of this kind can be expected to accomplish in theoretical geology. The deductions having quite outrun observation, Mr. Hopkins re-surveyed the Weadden, with a view to the detection of its dislocations; and his theoretical chart might almost be taken as an accurate map of the country. Now, in this application of the theory, there is an achievement quite beyond any mere probable explanation of the *law of parallelism*. This law, although still the prevailing one, is interfered with and subjected to great modifications by the *shape* of the district—modifications, however, of a fixed and determinate nature, flowing from the same actions which caused the law of parallelism itself; and every *predicted* deviation of the lines of fissure or dislocation from rectilinearity and accurate parallelism, as well as every predicted new relation of the transverse lines to the longitudinal ones, agrees, with an exactness altogether remarkable, with the facts elicited by a careful scrutiny of the region.

It appears probable that a legitimate way is now opening towards the resolution of the ultimate problem of the upheaving force. The agreement of deductions from the scientific hypothesis, with actual phenomena in difficult and complex cases like that of the Weadden, goes far to establish, that all dislocations of strata, and the accompanying mountain chains, have resulted from the upheaval of large portions of the earth's surface, by a diffused and equable energy—an energy concentrated into one point or district, only when it has produced craters of elevation. Accepting instruction from the surface of the Moon, we have certain lights also, regarding the *History* of the development of this force; for while its concentrated action, with its varied and remarkable craters, has evolved nearly all the mountain forms in that luminary—even as we find it assuming the almost obliterated ancient forms of the earth; its operation in raising extensive zones, now so frequently and characteristically established in our own planet, has yet scarcely appeared in the Moon. The one small doubtless comes, when, viewing it as an igneous speculation concerning the Theory of Elevation. It seemed to those eminent philosophers, that as the moon either now washes one *belt of every* great mountain range, or did so in former times (a fact necessarily resulting from the abruptness of one face of the chain), we must recognise an agent of elevation in the possess and operation of the sea; and they conceived they had discerned the mode of the requisite action, in the fact, that as the waves, by wearing down the coast and depositing its detritus at their bottom, must alter the vertical rightness of the land in those localities; they will, as a natural consequence, disturb the previous position of the isothermal surfaces within the earth's crust, and produce disturbance and probably dislocations. The proposed explanation, however, is incapable of comprehending the phenomena of the problem. 1. It assumes the existence of inequalities of vertical contour, inasmuch as it assumes a line of coast; and the existence of such inequalities is precisely the feature of all our planetary bodies, which this portion of geological theory is required to explain. 2. It is not true that elevation takes place only along coast lines. The vast zone in Scandinavia that is now rising, has no relation to the sea; nor have those phenomena which Darwin recognised in the Pacific. 3. The elevating force is evidently a *planetary* one; and no adequate explanation can be accepted which will not apply to other worlds than the earth. But in the moon, though characterized by every conceivable form and mode of fracture, no ocean exists, and, in all probability, matter in the liquid state cannot yet been developed on its surface.

[1] It is unfortunate for our elucidation of the subject, that the space to which we are limited, will admit of only a general reference to the theory of *veins and faults*, so fully developed in Mr. Hopkins' Memoir, in the *Cambridge Philosophical Transactions*; nor can we do more than mention his having demonstrated in the *Transactions of the Royal Society*, of the true law recognised by Mr. Phillips, that in the case of a *fault*, the displaced beds are lower on that side of the fault, towards which the plane of the fault inclines from the vertical, in *descending*. The power of any theory to exhibit such minor laws as unexpected deductions from its general principles, constituting the strongest presumption of its truth, we shall hope that Mr. Hopkins will apply the one now engaging his attention, to those more important and characteristic features of our mountain chains, which do not flow from their *elevations*. One of these is especially noticeable, viz., the fact, observable also in the case of the Lower Apennines, Alps, Cordilleras, &c.—that our great ranges are abrupt on one side—almost precipitous even, in their descent to the plains or the level of the sea, while on the other side they slope away through a long high land. There can be little doubt that this remarkable feature arises out of the manner in which the chains were upraised, and is no consequence, as has often been supposed, of subsequent modifications of their forms; and it appeared so important to Sir James Hall, and Mr. Playfair, that they employed it as a fundamental characteristic in an ingenious speculation concerning the Theory of Elevation. It seemed to those eminent philosophers, that as the ocean either now washes one *face of every* great mountain range, or did so in former times (a fact necessarily resulting from the abruptness of one face of the chain), we must recognise an agent of elevation in the possess and operation of the sea; and they conceived they had discerned the mode of the requisite action, in the fact, that as the waves, by wearing down the coast and depositing its detritus at their bottom, must alter the vertical rightness of the land in those localities; they will, as a natural consequence, disturb the previous position of the isothermal surfaces within the earth's crust, and produce disturbance and probably dislocations. The proposed explanation, however, is incapable of comprehending the phenomena of the problem. 1. It assumes the existence of inequalities of vertical contour, inasmuch as it assumes a line of coast; and the existence of such inequalities is precisely the feature of all our planetary bodies, which this portion of geological theory is required to explain. 2. It is not true that elevation takes place only along coast lines. The vast zone in Scandinavia that is now rising, has no relation to the sea; nor have those phenomena which Darwin recognised in the Pacific. 3. The elevating force is evidently a *planetary* one; and no adequate explanation can be accepted which will not apply to other worlds than the earth. But in the moon, though characterized by every conceivable form and mode of *fracture*, no ocean exists, and, in all probability, matter in the liquid state cannot yet been developed on its surface.

MAP OF THE MOUNTAIN CHAINS OF ASIA AND EUROPE,

WITH

A GEOLOGICAL MAP OF JAVA, SKETCH OF THE VOLCANIC KINGDOM OF LUZON, &c.

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INTRODUCTORY NOTE ON OROGRAPHIC REPRESENTATION.

The art of pointing out mountains on general maps has had to go through different stages of development, and it cannot be asserted that it has yet reached perfection. We have long been satisfied with expressing the existence of mountains by symbolical signs, and even in our own day we seldom go further, as in the case of the present map. Only the form of the symbolical sign has changed. Till the beginning of the nineteenth century, mountain chains were pointed out on maps of the whole globe, as well as on general maps of individual countries, by small elevations put together in a row, which had very much the appearance of hay-ricks in a meadow, or mole-hills. It cannot be denied that this method of pointing out mountains is graphic—in nature we see the mountains from one side, and not from the bird's eye view; consequently it was very natural to endeavour to represent them perspectively, and to make them agree as much as possible with a geometrical sketch. This, however, was often done at the expense of geographical accuracy. If I mistake not, the opinion that the hay-rick method was not sufficient for conveying an orographic image, which had the least claim to geometric accuracy, originated in Germany. It was thought necessary to give up the profile view of mountains, and give its due to the bird's-eye view, if correct ideas were to be conveyed on the extent of mountain chains and their directions. It was thought that this could only be done by pointing out the sloping part of the mountains by shading lines, as had been the case long ago with topographical and other maps on a large scale. This opinion has obtained prevalence in Germany, and from thence spread to Great Britain, France, &c.; although it is by no means rare to find, even now-a-days, nicely engraved mole-hills, prettily grouped, on maps. The new symbolic sign has given rise to many mistakes, and even to orographic errors. There was a time when our maps were filled with a mass of short shading lines, which ran on both sides of a narrow white space, which represented the ridge of a mountain chain, and turned with most fantastic windings round the sources of rivers;—and by mistaking the notion of water-sheds for mountain ridges, chains of mountains were placed in countries and localities which are distinguished for the evenness of the ground. Another error originated in the circumstance, that certain authors filled the plains of general inclination, from the beginning of the ridge of a mountain chain, or even, perhaps, from an individual peak, to the extreme point in the valleys of the principal rivers, with a mass of shading lines which followed the same inclination. This has called into existence strange maps, in which one "cannot see the forest for its trees." The principal merit of a map, besides its geographical accuracy, consists in the distinctness of the objects represented. It is quite contrary to that fundamental condition of a good map, to represent all geographical peculiarities on the same map. Their separate and distinct representation is necessary, if geographical designs are to fulfil their object. The author has proceeded on this principle, which is considered correct by many competent authorities. By employing the symbolical sign of shading lines in general maps, the attempt has been made, not only to point out the mountain chains in their principal directions, but also to give a notion of their relative height, by adopting a scale of shading lines, so proportioned to the white surface of the paper, that, generally speaking, the highest mountains were most deeply shaded, and the lowest most lightly. The principle in itself is correct; because, in topographic drawing, the proportion of the black line to the white space gives some indication which approximately informs us of the size of the sinuosities of an inclined plane. The value of these sinuosities rises or falls, the nearer or the more remote the lines of equal height are to each other. But even in topographical representations, the geometrical foundations of the drawing of inequalities of the ground have seldom been made use of. The measuring of heights, and, consequently, the tracing of the lines of equal height, have been neglected.[1] We have been satisfied with an average valuation of the sinuosities by which representations of surfaces have been formed, which, notwithstanding its beauty of appearance, cannot lay any claim to hypsometric or orographic accuracy. If the want of that element of drawing surfaces of ground be felt in topographical representations, how much more must this be the case in general maps, which have to represent one or several entire systems of mountain chains? What scope is here left to the imagination of the draftsman! which, as experience shows, has too often led him away from the truth. Talent will not allow itself to be confined within the limits of geometrical space; it overleaps them at the expense of geographical correctness. The smaller the effort, so much the better for the orographical image; the greater, so much the worse. In these circumstances, geographers and amateurs of geographical, and especially of orographical maps, will perhaps be surprised that I have made use, in representing the mountain chains, of such an extraordinary and rarely used symbolical sign as a straight black line, instead of hay-ricks, mole-hills, or shading lines. I will be evident at the first glance that such a sign is convenient on a map, which has to represent in a small space the geographical situation, distribution, and direction, of the mountain chains of entire continents. It is, however, another question, whether it will be generally liked, and may not offend against taste. The author, as a party, is unable to solve this question, and must leave it to connoisseurs of physical geography. It is scarcely necessary to observe, that for this map use has only been made of the most accredited accounts and the best authorities, including, for the interior of Asia, Alexander Von Humboldt's master-work. On the other hand, however, the author considers it to be his duty to point out the countries the orography of which admits of the greatest doubt. He does not wish to contribute to the great disadvantage which has arisen, and perhaps still arises, to the study of geography, from the circumstance that the imagination of many geographical draftsmen has run away with their pen or their pencil, by which means maps have been called into existence of great Asiatic countries—nay, of the whole continent—which show such apparent accuracy, as if they were based on the most complete trigonometrical measurements and geological surveys made by such men as Leopold Von Buch, Murchison, &c., with the greatest detail.[2] Among those territories, of the orographic condition of which we have only dubious knowledge, we must, above all, reckon China, Manchouria, and Posterior India. No one should be deceived by the apparent accuracy of the mountain chains which are represented in these countries, as every thing remains still to be done for the investigation of the geological condition of all the countries of Eastern Asia. What we know of it is only in fragments, the first rudiments—which in China for instance, have been afforded by the map of the Jesuits, published by D'Anville. But besides these, the author made use of a manuscript map which was communicated to him in the year 1827, by his late friend, the great Chinese scholar Julius Klaproth, which he had projected from several maps and geographical writings of the Chinese Let us hope, and I do not doubt, that after England's victorious arms have opened up the coasts of China, access will be gained to the interior of the Celestial Empire, and that European observers will yet fully disclose to us the wonders of nature and art in that singular country. It is a triumph of the spirit manifested in Christianity, that all must bend before it,—Mohammed, Buddah, and the millions of their believers. England is, at the present day, in the hand of Providence, the disseminator of this spirit over the whole world. For Posterior India I have made use of the excellent reports, accompanied by maps, which have been lately published in the Journal of the Asiatic Society of Bengal, and which have considerably enriched the geography of the distant East, although there still remain great desiderata relative to a knowledge of the mountains. Much has been written and compiled in Germany on the alpine countries between Tibet, China, and India beyond the Ganges; but the author frankly confesses, that from all these publications, notwithstanding their extent and supposed exhaustion of the subject, he has not been able to form a distinct image of the directions of these mountain chains. It is possible that the fault may lie in his preconceived notions on the subject. He has called this territory *Terra Alpina incognita*, and has brought the great stream of Tibet, the Yarou-Tsanpo-Tsiou, in connection with the Boumpoutra. This, as is well known, is a geographical puzzle, and the subject of a controversy. Can there not be found in the great Indo-British empire one bold man who would undertake to go up the Dihong, to see whether this river is the prolongation of the Yarou-Tsanpo-Tsiou? It is upwards of twenty years since England got possession of Assam, having had for as long a time a garrison at Sudiya, at the source of the Dihong in the Abor country, and she ought to be ashamed that she has not yet made an attempt to solve the problem in question.

H. BERGHAUS.

MOUNTAIN SYSTEMS OF THE OLD WORLD.

On this map the principal characteristics of the geognostic condition of the Asiatic and European continents, including the north-eastern territory of Africa, are represented. The direction and extent of the principal mountain chains—the data as to the highest or culminating points—the table-lands—the valleys—the plains—the volcanoes, and other vents—have been everywhere, as far as measurements have been made, pointed out, giving the elevations in English feet. As the object of the map is simply to indicate the mean directions of the principal elevations which compose the frame-work of the Old World, with a view to explain chiefly their relation to parallelisms, all minuter details have been omitted.

Astronomical and hypsometrical observations are the essential foundations of geography—the only stable elements of maps; and, by their application, the Asiatic portion of the sheet before us presents an appearance very different from that of the ordinary maps of this continent. The mountain ranges in the interior of Asia have hitherto been very little understood, and most erroneously represented. In the following notes, we shall give an outline of their arrangement, according to the great naturalist, who, in his late comprehensive work, has thrown so much light on this important subject. "Central Asia," says Humboldt,[3] "presents, in the general form of its relief, a remarkable simplicity of structure. The frame-work of this middle portion is composed of four systems of mountains, almost uniformly directed from W. to E., and parallel with the greatest dimensions of the continent." These he designates by the names of the *Altai*, the *Thian-shan* or Celestial Mountains, the *Kuen-lun*, and the *Himalaya*. South of the Himalaya, in the Indian peninsula, there are traces of the same mass of elevations, following, more or less regularly, the direction of the parallel of the equator. Opposite the Himalaya is the small system of the *Vindhya*, which has been called the central chain of India: its direction is nearly S. 75° W. South of the Vindhya is the nearly parallel chain of the *Sumpoora*. In the triangular peninsula of India, as in that of South America, it is the western side which is bordered by the most elevated Cordillera. The chain of the *Ghats*, or *Ghauts*, of *Malabar*, forms a rocky wall of a very simple structure, extending from N.N.W. to S.S.E. The *Ghauts of Coromandel*, or the Eastern Ghauts, which are much less elevated, and much interrupted, follow the opposite direction, N.N.E. to S.S.W.

The resemblance between the direction of the axes of elevation, and the contours of the nearest coast is very remarkable. Opposite the Western Ghauts, where the chain of Hadramaut, on the coast of Arabia, turns abruptly towards Oman, this is strikingly exemplified. On the east of Oman, the coast chain is directed from N.E. to N.W., and preserves a mean height of from 3,000 to 3,500 feet. The Western Ghauts, so remarkable for their continuous length (upwards of 170 leagues), the simplicity of their structure, and their powerful influence over the ambient atmosphere, do not generally exceed from 3,000 to 5,300 feet in elevation; at their southern extremity, where the Eastern and Western Ghauts seem to unite, rises the great mass of the *Nilghereey Mountains*, the culminating point of which is 9,941 feet in elevation. The plateau of the Nilgherries (or Blue Mountains) is only 7,000 feet in height which is about 2,500 feet lower than the base of the city of Quito. The meridian ridge of the *Ourul* is a wall, or rather an assemblage of parallel, ridges 240 leagues in length, the main axis of which ranges between 57° 20′ and 60° 20′ E. long.; it changes this uniform direction, perhaps abruptly, to the N. of lat. 60° or 61°, and it is, probably, continued to the island of Waigats in Novaia Zemlia. This rapid sketch may suffice to indicate, in the meridian ridges which bound Interior India on the west, one of the traits which unite all that is most salient and characteristic in the *relief* of the continent. The line of elevation, in the direction of S. to N., extending from Cape Comorin to the borders of the Icy Sea, comprising the *Ghauts*, the chain of *Soleymann*, the *Bolor*, and the *Ourul*, is, notwithstanding its interruptions and partial sinuosities, "one of the most remarkable phenomena afforded by the hypsometrical examination of the surface of the globe." To the west of the Indus rises the high chain of *Soleymanee*, and beyond the table-land of Afghanistan is the remarkable system to which the classical name of *Zagros* has been applied.

In India beyond the Ganges, the meridian ridges mark, in Upper Assam, the crossing of the different systems, which correspond to the Southern Ghauts. This crossing gives rise to the parallel chains of Cochin China, Siam, Malacca, Ava, and Aracan.

The two meridian and opposite systems, bounding the Bay of Bengal, are accompanied, very symmetrically, towards their extremities, and at their submarine western slopes, by innumerable islets, connected, in long narrow bands, from N. to S.; those are, on the west of the chain of Malacca, the Andaman and Nicobar islands; and, to the W. of the Ghauts of Malabar, the archipelagoes of the Laccadives, Maldives, and Chagos. On the N.E. of Asia, the mountain ridges are less simple in structure, and less uniform in direction than the Ourals on the west. As the range of the Bolor terminates the basin limited by the Kuen-lun and the Thian-shan on the west, so the basin between the Thian-shan and the Altai, entirely open on the west, is enclosed on the east by the meridian chain of the *Khing-han*, to the Amour or Sagalien river on the north.

The system of the *Altai* surrounds the sources of the Irtish and Yenesei. Beyond the Knot of Kemtei on the east it joins the systems of Khinggan and Yablonoi Krebet. The *Altai* proper,[4] celebrated for its metallic mines, forms little more than a fourth part of the entire system; it comprises a mass of mountains, which advances like a vast promontory to the western extremity of the chain, covering an area nearly as great as England, or three times larger than Bohemia, and nearly four times the size of Switzerland. The most prominent masses of this system, attaining the limits of perpetual snow, are situated between the parallels of 47° 20′ and 51° N. The *Meletz* chain, which rises in some parts to upwards of 4,000 feet above the sea, and is of enormous breadth, appears to separate two regions of the atmosphere, which differ in many respects meteorologically; the eastern slopes enjoying a mild coast climate.

In the mountain systems of the north-east of Asia, beyond the Altai, the ridges from S.W. to N.E. are of little extent and elevation when compared to the four great chains from E. to W. (the Himalaya, Kuen-lun, Thian-shan, and Altai), which constitute the frame-work of Central Asia.

ESSAY ON THE MEAN HEIGHT OF CONTINENTS,

BY BARON ALEXANDER HUMBOLDT.

READ IN THE ROYAL ACADEMY OF SCIENCES, BERLIN, 30TH JULY 1829.

Among the numerical elements, upon the exact examination of which the progress of physical geography depends, there is one which hitherto has almost never been attempted to be defined. The belief that it was impossible to make any such definition has perhaps been the principal cause of this neglect. The extension, however, of our orographical knowledge, as well as the greater perfection of maps of great territories, has encouraged me to prosecute, during a number of years, a laborious, and, as it may appear, unpromising task; the object of which was to arrive approximately at a knowledge of the mean heights of the continents, and a definition of the height of the gravity of their volumen. In this inquiry, as in many others concerning the dimensions of the globe, it is necessary to ascertain the limiting numbers between which the results are to be found, and to proceed from what is known to an individual country—as, for example, from the surface of France, which is geometrically as well as hypsometrically sufficiently known—by degrees to greater portions of Europe and America, led by analogies, and, at the same time, searching for every numerical notice which, of late, more especially for inner and western Asia, have increased to a very desirable extent. Astronomical measurements of places had to be most carefully collected, in order to ascertain the limits between the mountain slopes and the borders of the plains up to 1,000 and 1,200 feet absolute elevation. "I have formerly shown, in geognostic inquiries in South America, the possibility of ascertaining the limits and a comparison of the surface of the plains and bases of the mountains which depend on them, in a country where the long Cordilleras de los Andes, which are raised like a wall on an immense crevice, and the elevation of the masses of the Parima and of the Brazils, are so incorrectly defined on all the older maps." It is the general tendency of all graphic representations, to give to the mountains more breadth than they have in reality; nay, even to confound in the plains the table-lands of different orders.[5] The great geometer, Laplace, had expressed the hypothesis, that the correspondence which is to be found between the results of the experiments made with the pendulum and those on the flattening of the earth, which was deduced from trigonometrical measurements of degrees, and the inequalities of the moon, afforded proof "that the surface of the terrestrial spheroid would be nearly that of the equilibrium, if that surface became fluid

[1] See Map of Europe, constructed on the principle of contour lines, No. 1. of this division.

[2] M. De la Condamine says: "The greater part of our maps are loaded with details imaginary, and yet circumstantial." From stories, the same types have been followed, and by a principle of stability and conservatism opposed to progress, the evidence of travellers has been neglected, rather than ascribe a water-course, a chain of mountains, or a littoral sinuosity, which has been figured for ages, and thus many rarely express the state of knowledge at the time of their appearance.

[3] Asie Centrale, tome i., p. 196.

[4] The common distinction of "great and little" Altai is founded on error: both the name and the chain of the great Altai are imaginary.—*Asie Centrale*, i. 251.

[5] Baron Humboldt first treated on the mean heights of continents in the year 1825, in two essays, which he read before the Royal Society of Paris, entitled: "L'exaltation du volume des aréres et exaltement des montagnes, compare à l'étendue de la surface des basses régions." A memorable assertion of Laplace, in his *Mécanique Céleste*, tom. v. lib. 11, ch. 1, p. 9, had been the means of bringing on the inquiry.

Connections IN EUROPE.

B.W.... Boleroy Wald
B.Bl.... Bilmer Wald
Bret.... Systm. of Bretagne
C.... Romb. de Gatbl
C.d'Or.. Côte d'Or
Esp.... Aspromch
F.D.... Fichtel. Gebirge
Lo.... La Lozere
L.... Chain of Lebenon
M.... Sierra de Moncayo
Mon.... Montagnes du Morvan
M.Bl.... Mont. Blanc
P.d.D.. Puy de Dome
R.G.... Rumen. Gebirge
S.Gen.. Sierra de Gennat
S.E.... Estrella
S.G.... Gerez
S.Gr.... Gredos
S.Gu.... Guadarrama
S.S.... Xouda
S.R.... de Ronda
Su.W.. Schwarz Wald
T.W.... Teutoburger Wald
Th.W.. Thüringer Wald
V.... Mont Ventoux

Raising [illegible] of the ISLAND OF REGUAIN.

Geographical Miles

NOTES on the PLAN of the I. of REGUAIN.

Surveyed by Lieut. M.ᶜ Volloih R.N. H.M. Brig Childers, 1841.

As in Europe the Coasts of the Scandinavian and Italian Peninsulas, so also in Asia the Coast of Arracan offer the phenomenon of a progressive Raising of the ground.—

The Island of Reguain, and its vicinity, the Islet of Reguain, situated both in the prolongation of the great Volcanic Band of the Sunda Islands, present this phenomenon in a very remarkable manner. On Reguain we distinguish three periods of Raising.—Shows the beach of the original Island.—Via Volcano now its centre, about 90 feet above the Sea.—Represents the beach of the land subsequently raised; this eruption commenced with the power it had South of the point ○ of the 1ˢᵗ beach.—○ is a very small volcanic mount from which issues a quantity of petrolium. The outer portion of the Island was raised about 30 years ago.—c was a small Islet before the last eruption; the Island line which surrounds it and also the one further Southward were apparently sand banks.—b Denotes a well.—d Soft marshes.—e Former streamlets.—The marks ⁄// denote masses of coral, and in other rock, they completely cover the outer or last formation, the 2ᵈ formation has but a few here and there, and the original Island is entirely clear of them, with the exception of a slight sprinkling near the streamlet at its northern point.—The land last raised is quite uncultivated, the remainder of the Island is one large paddy field.—I.A. Icome of several rocks on the last raised land which exhibit a water line A the same height as that of the 2ᵈ formation.—The whole Island consists of three perfect Circles different by five feet in height, the inner one having at its centre a Volcano about 90 feet above the sea.—The water is very shoal to the Northward, and also on the Eastern side of Reguain.—L. Landing place.—s. Specimens of the soil taken from spot thus marked.—The Islet of Reguain is situated in Latitude 10°.37'.30" N. Longitude 98°.49'.45" E. Greenwich.

GEOLOGICAL MAP of JAVA.

EXPLANATION of the GEOLOGICAL MAP of JAVA.

By Dr Thomas Horsfield.

a Volcanic Region, the Volcanoes, in state of activity or extinct, are marked thus ○. Dr Horsfield gives the following information:

Gedeh and Pahaha: Crater in a state of partial activity. Salak: Crater last eruption 1761. Tankuban Prahu: Crater discharging Sulphurous Vapours from various apertures. From Tile to Chikuras extinct Volcanoes. Papandayung, the Crater fell in in 1772. Guntur: Crater last eruption about 1647. Mauglayang and Maruyung extinct Volcanoes. Cheremai: Crater last eruption in 1805. Talaga Bodas: Crater with a lake with water. Ungerang: Crater extinct. Lawu: Crater discharging sulphurous vapours. Klut: Crater exploded in 1765. Arjuna: Crater discharging Smoke. Dasar: Crater last eruption in 1804. Lamongan: Crater exploded in 1806. Ringgit: Remains of the Crater which fell in in 1586 according to Valentyn. Tashem: Crater last eruption in 1286.

b Secondary Volcanoes. 1. Extinct Crater or secondary Volcanoes mixed with Hills of Limestone especially near the Sea where the limestone rocks are piled up to great heights; here Basalt & Kieselm. Breccia in the beds of rivers, also Porphyry, Aegyer, Greenstone, Agate, Obsidian, in some places Quartz, appearing in Rock-crystals, Prisms or Amethyst, rarely Siliceous petrifaction.—2. Mixed calcareous rock-sand ridges imposed upon or alternating with Volcanic rocks.

Valley the basis of which is gravel in irregular concretions or in immense strata frequently called ... cubical form, called Tabias by the Javanese.

Alluvium. 4. Near the Sea immense piles of Calcareous rocks with large excavations.—5. Low sandy District.

In the Calcareous Region, which is coloured light green, the District of Surabaya (3) consist of Alluvium ... creating on a Calcareous basis.... c
... together as Sand-stone in a flat or ... d
... basalt ... e
... of the Teak forests.

Heights above the Sea of various Mountains of the Island of Java.

Measured by means of a barometer by Dr Fr. Junghuhn 1840.

The points, precised with a * were determined by Sir Thos Stamford Raffles, Professor Reinwardt & others.

*Karang, (Ujung)	5862ft	*Tombak Pacyung		*Talaga Bodas	5400ft
Buitenzorg (Java)	550 "	*Telu		Slamat or Gedé, Mountain of Tegal	11029 "
Gedeh, the highest Peak of the Mountains of Salak	6962 "	Guntur, the highest brink of the crater wall on the N.W. side	6349 "	Prahu	6330 "
Masellawangie, the S.E. brink of the Crater	7245 "	*Sumbung		Di-eug, a little plateau with Solfataras	8710 "
Gedé, the highest N. brink of the Crater	8969 "	Malabar, the highest Eastern Peak	8037 "	Sindoro, the top of the plateau	10729 "
Patuha, the highest crater brink, named Tossuan-coast	7856 "	Wayang (Wyahan), the Solfatara	8146 "	Sumbing, the highest of the western crater-wall	11029 "
Tankuban Prahu, the highest point of the southern wall of the crater	6627 "	Papandayang, in the middle of the crater	8054 "	Sumbing, on the ground of the crater	10512 "
		*Chirukui	5427 "	Merbabu, the highest peak, or the N. side	10023 "
				Merapi, the highest p...	
				Sura kerta or Solo	9200ft
				Lawu, the highest top	8727 "
				Wilis, highest top nam...	8484 "
				*Arjuna	10680 "
				Dasar, Crater of the H...	7054 "
				*Tashem	6305 "

EXPLANATION OF THE CHARACTERS USED IN THE BODY OF THE MAP.

Mountain Chains. ..... Undetermined Signs of the same. Slope and Base of the mountainous and hilly regions. ○ Culminating and other Summits of the Mountain Chains with their height in feet. ▲ Volcanoes.

All the names which have not a relation to the Orography are expressed in light letters, thus (Hungary, Gobi.)

Longitude E. from Greenwich

MOUNTAIN CHAINS IN ASIA & EUROPE

Extended, from the original drawings of Professor Berghaus.

BY A.K. JOHNSTON, F.R.G.S.

Comparative View of the MEAN HEIGHT of the CONTINENTS.

Comparative View of the height of the Crest And of the CULMINATING POINTS of the GREAT MOUNTAIN-CHAINS by Baron Von Humboldt.

Andes of Bolivia — Andes of Quito — Himalaya — Pyrenees — Alps of Switzerland

Level of the Sea

SECTION of the CONTINENT OF ASIA from South to North along the Meridian of CAPE COMORIN.

The Plains of Siberia

Level of the Sea

Geographical Miles 60 to a Degree.

English Miles 69 ½ a Degree.

VOLCANIC KINGDOM OF LUZON.

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A.K. Johnston.

From this, and from the circumstance that the sea leaves vast continents uncovered, we conclude that it can have no great profundity, and that its mean depth corresponds with the mean height of the continents and of the islands which rise above its surface—a height which does not exceed 1,000 metres (3,280 English feet). This height is, then, a small portion of the excess of the semi-diameter of the equator over that of the pole—an excess which exceeds 20,000 metres (66,616 English feet). In the same manner as the high mountains rise above some parts of the continents, there might, perhaps, also be great cavities in the basins of the seas; but it is natural to think, that their depth is less than the elevation of the high mountains—the depositions of rivers and the remains of marine animals suffering in time to fill up these great cavities." If we consider the versatility of talent, and the profound knowledge, by which the founder of the Mécanique Céleste was distinguished in as high a degree, we must perceive such an assertion to be the more striking, as it could not escape him that the highest table-land of France—that in which the extinct volcanoes of Auvergne have broken through—is, according to Ramond, only 1,110 feet, and the great Iberian plateau, according to Humboldt's measurements, only 2,300 feet above the level of the sea. Laplace has fixed the upper limit only at 3,300 feet, because he considered the circumference and the mass of elevation of the mountains to be far more considerable than it really is, having mistaken the elevation of individual peaks for the mean height of the ridges of the mountains, and being afraid of fixing the mean depth of the sea too low; and lastly, because in his time he had no data from which conclusions might be drawn as to the relations of the surface, in square miles, of all the continents, to the surface of the bases of the mountains. An accurate calculation gave the result, that the mass of the Andes chain of South America, if pulverised and equally distributed over the whole eastern plain, would raise its surface, which is exactly one-third larger than that of Europe, only about 518 feet. Baron Humboldt concluded at that time, from this fact, "that the mean height of continents depends much less on those longitudinal mountain chains, of little elevation, which traverse the continents—those culminating points or domes which attract the curiosity of the vulgar—than on the general configuration of the table-lands of different orders, and upon their ascending series—upon their gently undulating plains and alternate slopes, which exercise, by their extent and mass, an influence on the position of a mean surface; that is to say, upon the height of an angle which is placed in such a manner that the sum of the positive is equal to that of the negative elevation." The comparison which Laplace makes, in the passage above quoted of the Mécanique Céleste, between the depth of the seas and the height of the continents, reminds us of a passage in Plutarch, 15th chapter of his Biography of Æmilius Paulus. (Edit. Reiske, vol. ii. p. 276.) It is the more curious, as it makes us acquainted with a generally prevailing opinion among the philosophers of Alexandria. After Plutarch has communicated the contents of an inscription which was made at the the foot of Olympus, and pointed out the result of the careful measurement of the mountains by Xenagoras, he adds: "But the geometers [evidently those of Alexandria] believe that there is no mountain higher, and no sea deeper than 10 stadia." They placed no doubt in the accuracy of the measurement of Xenagoras, but they expressed an opinion that, by the structure of the earth, a complete equality ought to exist between the positive and negative heights. Here the question is, indeed, only of a maximum of the heights and of the depths, not of a mean state—a consideration which did not present itself to the ancient natural philosophers, and which was only introduced with regard to varying quotients, in a manner very beneficial to astronomy, by the Arabs. There is also an opinion expressed to the "Meteorologica" of Cleomedes (i. 10) which agrees with that of Plutarch; whilst in the "Meteorologica" of Aristotle (ii. 2) the mean height of the mountains is considered by the inclination of the bottom of the sea from E. to W. upon the currents. In endeavouring to fix the mean height of the elevation of the continents above the present level of the sea, we have to ascertain the centre of gravity of the volume of the continents above that level—an inquiry which is entirely different from that of ascertaining the centre of gravity of the volume, since the part of the solid crust of the earth which rises above the sea is by no means of equal density, as geognosy and experiments with the pendulum have shown. The way to proceed with the simple calculation is this: We have to consider any mountain chain as a three-sided horizontal prism, which rises perpendicularly to the plain which forms the basis of the mountain chain. The plateaux have been calculated according to their contents as standing prisms. To give an European instance, I may mention that the surface of France contains 10,087 German square miles (161,392 English miles). According to Charpentier, the surface of the base of the Pyrenees amounts to 450 German square miles (7,720 English miles). Although the mean height of the ridge of the Pyrenees amounts to 7,896 feet, I have, nevertheless, adopted a lesser height, on account of the inequalities of the lying portions, which form the frequent deep lateral valleys, decreasing the volume. The effect of the Pyrenees on the whole of France is only 114 feet; this is nearly the amount to which the normal surface of the plain of the whole of France would be raised; which normal surface is found, by comparison of many accurately measured places in good situations—i. e. near the centre (Bourges, Chartres, Nevers, Tours, &c.)—to be 510 feet. The calculation gives the following general result:—

1st, Effect of the Pyrenees, 113 feet.

2d, French Alps, the Jura and the Vosges mountains, some toises more than the Pyrenees. Their common effect, 120 feet.

3d, There remain the plateaux of the Limousin, of the Auvergne, of the Cevennes, of Averyon, Forez, Morvan, and the Côte d'Or. Their common effect, very nearly the same as that of the Pyrenees, is equal to 115 feet.

Now, as the normal height of the plain of France, in its widest extent, amounts to 510 feet, so the mean height of France, at the most, is 870 feet.

The Baltic, Sarmatian, and Russian plains, are only separated by the longitudinal chain of the Ourul from the plains of Northern Asia; wherefore Herodotus, to whom the connection around the southern extremity of the Ourul and the country of the Issidons was known, calls all Asia north of the Altai, Europe. In that part of the Baltic plains on this side of the Ourul, near the coast, there are some partial elevations of masses, which require particular notice. West from Dantzig, between this city and Dirtow, where the sea-shore stretches farthest north, there are many villages situated 425 feet above the level of the sea; and the Thurmberg (lat. 54° 13′ 29″) rises to 1,000 feet—perhaps the greatest elevation between the Harz and the Ourul mountains. In Livonia and Eastern Prussia, the Baltic plains have also inconsiderable of more than 640 feet. It is a striking fact, that, according to Struve's measurement, the culminating point of Livonia, called Munna Maggi, is 1,061 feet in elevation, and consequently approaches within a few feet of the height of the Thurmberg, 8″ farther west.[1] Nay, that there is as great a correspondence between the deepest part of the Baltic (between Gothland and Windau) and this elevation—this depth amounting to 113 fathoms,—if we suppose the Thurmberg to be 181 fathoms high. The exclusively European plain, the normal height of which cannot be calculated at more than 380 feet, has, according to accurate measurement, nine times the surface of France. The immense extent of this low region is the cause that the mean continental height of the whole of Europe, with its 170,000 German square miles, is by 190 feet lower than the result for France. Without dwelling longer on these calculations, I only add the consideration, which is not quite unimportant in a general prognostic view, that elevation of masses of whole countries, in the form of plateaux, produces quite a different effect upon the increase of the point of gravity of the volume from mountain chains, however considerable they are in length and height. Whilst the Pyrenees produce upon the whole of Europe scarcely the effect of 6 feet, and the system of the Alps, the surface of the base of which surpasses that of the Pyrenees nearly four times, the effect of 22 feet, the Iberian peninsula, with its compact plateau mass of 1,920 feet of elevation, produces an effect of 76 feet. The Iberian peninsula, consequently, produces upon the whole of Europe an effect four times as great as that of the system of the Alps. The result of these calculations is so surprising, that it seems impossible to form any idea of it beforehand. Of late, a good deal of light has been shed on the formation of Asia. The effect of the southern colossal masses of elevation is diminished by the circumstance that one-third of the whole continent of Asia—a part of Siberia, which alone surpasses by one-third the surface of the whole of Europe—has not more than 255 feet of normal height. To this amounts the elevation of Orenburg, and the northern border of the Caspian and Turanian declivity. Tobolsk has not half that height; and Kasan, which is five times the distance from the coast of the Arctic Sea that Berlin is from the Baltic, has scarcely half the elevation of the Prussian capital. We found on the Upper Irtish, between Bukhturminsk and the Dzaisan Lake, on a point nearer to the Indian than the Arctic Sea, that the plain was not 830 feet high—a so-called central plateau of Inner Asia, which has not half the elevation of the streets of Munich above the level of the sea. The table-land, formerly so famous, situated between the Baikal Lake and the Chinese wall (the stony desert of Gobi or Shamo), which the Russian academicians, Bunge and Fuss, have measured barometrically, has a mean elevation of only 4,220 feet: nay, this plateau has in its centre, where Ergi is situated (lat. 45° 21′), a hollow where the soil sinks down to 2,560 feet, nearly the elevation of Madrid. "This hollow," says M. Bunge, in an unpublished paper in my possession, "is covered with halophytes and species of artundo; and, according to the traditions of the Mongols who accompanied us, it was formerly a great inland sea." Both extremities of this hollow are bounded by flat rocks, like a sea-coast, true Ohm-Baishan and Tsakhilsk. The surface of the Gobi, in its uniform elevation of masses, from S.W. to N.E., is twice as large as the whole of Germany, and would raise the point of gravity of Asia by 128 feet; whilst the Himalaya mountains, and the Kuen-lun, a continuation of the Hindoo Koosh, together with the Tibetan plateau, which connects the Hymalaya and Kuen-lun, would produce an effect of 358 feet. In calculating the immense relief between the Indian plains and the low plateau of Tarim, which slopes from the Kashgar in an easterly direction towards the Lopnor, a point was to be attended to near the meridian of Kuglass (Gang-dis-ri), and the holy lakes of Mansurowar and Rawun Rhada, from which the Hymalaya mountains no longer run from E. to W., in a direction parallel with the Kuen-lun, but join, in a S.E. to N.W. direction, the mountain-knot of Tsung-ling. The elevations of the numerous mountain passes from Bamian to the meridian of the Chumulari (26,800 feet), through which Turner arrived on the Tibetan plateau of Lassa, are known through an extent of 21° of longitude. The greater part of them are very uniformly 14,000 feet—an elevation not at all uncommon in the passes of the Andes chain. The passes, as formerly mentioned, fix the mean elevation of the mountain ridges. In a paper on the relation of the culminating points to the elevation of the mountain ridges, I have shown that the mountain ridge of the Pyrenees, calculated from 23 passes (cols, beaucoups), is 320 feet higher than the mean height of the mountain ridge of the Alps; although the culminating points of the Pyrenees and the Alps bear a proportion of 1 to 1¼. As some of the individual passes of the Himalaya mountains, for instance (the three goats) Niti Gote, through which we pass into the plain of Cashmere, are 16,860 feet high; I have rated the mean height of the Himalaya ridge, not at 14,000, but, though perhaps overrated, at 15,700 feet. The plateau of the three Tibets of Iserdo, Ladak, and Lassa, is an elevation between two concurrent mountain chains (Hymalaya and Kuen-lun). Vigne's journey to Bultistan or Little Tibet, the journals of the brothers Gerard, as well as new inquiries made in India itself concerning the relative elevation of the eternal snow line on the Indian and Tibetan declivity of the Himalaya, have fully proved that the mean elevation of the Tibetan plateau has been hitherto considerably overrated.[2] The hypsometric configuration of the Asiatic continent, in which the plains and slopes are perhaps more striking than the colossal elevations, is distinguished by two characteristic features. 1st, By the long series of meridian chains, which extend with parallel axes, but alternating among themselves (perhaps interrupted, as it were, by dykes) from Cape Comorin (opposite Ceylon) to the coast of the Arctic Sea in a uniform direction of S.S.E to N.N.W., under the names of the Ghauts, the Sulymaun chain, the Belor, and the Ourul. The alternating position of these meridian chains, which are rich in gold, manifests the law that none of the meridian chains just named, between 64° and 75° of longitude, passes the next one towards E. and W.; and also, that every new longitudinal elevation begins only in that geographical latitude which has not yet been attained by the preceding one. 2d, Another characteristic feature of the configuration of Asia, which cannot be sufficiently attended to, is the continuity of an immense elevation from E. to W., between latitude 35° and 38° 30′ from Taktalu in ancient Lycia, to the Chinese province Ho-pee, an elevation which is three times crossed by meridian chains (Zagros in W. Persia, Bolor in Affghanistan, and the Asaan chain in the Tsungo valley). From W. to E., this chain is called respectively Taurus, Elburz, Hindoo Koosh, and Kuen-lun, or Aunenta. In the third book of the Geography of Eratosthenes, the first germ is to be found of the idea that there was a mountain chain which runs uninterruptedly, and divides the whole of Asia. (Strabo, xv. p. 689, ceb.) Dicæarchus saw the connection between the Taurus in Asia Minor and the Indian snow mountains which had become so celebrated among the Greeks, from the narrations and fictitious reports of the companions of Alexander the Great. Importance was attributed to the parallel of Rhodes, and to the direction of this immeasurable mountain chain. The "oblongæ" of Asia was said to be broadest under this parallel (Strabo, xi. p. 519); nay, farther towards the east there might be found (as Strabo says) another continent. There were strange geognostic dreams about a zone, a degree of latitude, and a fissure of that part of the surface of the earth in which there have been pre-eminently continental and mountain elevations, nay, in which are also to be found the straits and pillars of Hercules near Gades (Cadiz), lat. 36°. The Taurus and the plateaux of Asia Minor had first led the Grecian natural philosophers to observe the influence which is exercised by elevation upon temperature: "Also in southern zones," says the great geographer of Amaseia (Strabo, ii. p. 73), "in comparing the climate of the northern coasts of Cappadocia with the plain about the Argæus, which is 3,000 stadia farther south, the mountains and every highly situated soil is cold, although it may be a plain." Strabo alone, among all Grecian authors, makes use of the beautifully expressive word (Ὀρεινὰ) mountain-plains.

According to the final results of Baron Humboldt's calculations, the maximum of the mean continental elevation fixed by Laplace, is by two-thirds too great. He finds for the three parts of the globe which he has calculated (he would be rather premature to include Africa), the following numerical elements, which are stated in three different measurements:—

Europe	.	670 feet, 105 toises 204 metres.	
North America	.	730 „ 117 „	227 „
South America	.	1130 „ 177 „	344 „
Asia	.	1150 „ 180 „	351 „

Thus, the result for the whole new continent is 930 feet, and for the height of the point of gravity of the volume of all continental masses (Africa not included) above the present level of the sea, 1,010 Eng. ft. (157½ toises), 307 metres. Herr Von Hoff has, in the surface of 224 German square miles, measured with rare accuracy the elevation of 1,676 points, and that in the most mountainous part of Thuringia. He accordingly ascertained nearly five elevations in every square mile; but those elevations were unequally distributed. He finds his mean elevation 1,060 feet (166 toises), consequently only 50 feet more than is shown by Humboldt's results; we may conclude from this, that as a very mountainous part of Thuringia was measured, the result of 1,000 feet, as limiting number, is rather too great than too small. As it is ascertained that a progressive but partial rising of Sweden has taken place, we may conclude that this position of the point of gravity will not always remain the same, but taking into account that some masses are descending, and that the surface on which the subterranean forces are working seems to be small, the compensation which is thus in a great measure naturally brought about, will, on the whole, affect very little the point of gravity of what is above the ocean. In the numerical results of this hypsometric paper, we find anew that the lowest elevations in our hemisphere belong to the continental masses of the north, Europe affording 670, and North America 730 feet.

The elevation of Asia, between the parallels of latitude 28° and 40°, compensates the decreasing effect of the polar lands.

Asia and South America give respectively 1,150 and 1,130 feet. We may thus read, as it were, by these numbers, in what parts of the surface of the earth volcanic power has been, since remote times, most effectively at work in elevating the soil. (See Notes to Map of the Phenomena of Volcanic Action, No. 7 of this division.)

The small Map of the Volcanic Kingdom of Luzon, is constructed according to the author's chart of the Philippines, in his great Asiatic Atlas, where the majority of these fire-vents have been, for the first time, introduced into physical geography. (See Notes and Explanations in the Map of the Phenomena of Volcanic Action, Geology, No. 7.)

Geological Map of Java, according to Horsfield.—This Map is coloured geologically, according to the predominant mountain formations, and the colours are explained in the notes under the Map, where also the ascertained elevations are given in English feet. The hypsometrical knowledge of Java, for which there existed heretofore only a few data, was considerably enlarged by Dr. Fr. Junghuhn, in 1840.

Upheaval of the Island of Reunion.—The plan of this island deserves particular attention. In the Old World hitherto, these localities were known on which the phenomena of upheaving, by subterranean force, was visible, viz., Scandinavia, and other countries of the Baltic generally, the west coast of Italy, and the coasts of Cutch, between the mountains of India and Gujerat. A fourth territory of upheaving, however known in 1840, by means of the nautical measurements of the brig *Childers*, on the west coast of Arracan. From these it appears that the Island of Regnain, or *Pilot Island*, as well as all the other islets and rocks on that part of the coast of Arracan, is undergoing a process of upheaval. The whole coast from Akyab to Cape Negrais, is indented by deep and narrow gulfs, similar to the Fiords of Scandinavia; it lies within the prolongation of the great volcanic belt of the Sunda Islands, which extends from Java by Sumatra, Barren Island, and Narcondam.[3] All the islands on the coast of Arracan bear evident marks of subterranean fire; in the Island of Cheduba alone there are two mud volcanoes, which rise to a height of from 100 to 200 feet. This line of upheaval is, in the direction of N.W. by N., to S.E. by S., about 100 geographical miles in length, and varies in breadth from 20 miles to a very narrow stripe of islets and rocks. The upheaval has been greatest in the middle of the line; at the Terribles it was 13 feet; at different parts of the north-west reefs of Cheduba 22 feet; at the north point of the Island 16 feet; at the middle on the west coast 15 feet; at the south end 12 feet; and in the islands south of Cheduba to Foul Island from 12 to 5 feet. The first symptoms of upheaval appeared about the year 1750 or 1760, on the occurrence of a great earthquake by which the sea was driven over the land, and the effects of which were felt as far as the city of Ava. An earthquake is said to have occurred 100 years earlier; and the inhabitants believe that a similar phenomenon occurs every century. The different portions of upheaval are indicated by colours on the plan, and the points ascertained in the survey are explained in the notes by which it is accompanied.

[1] Compare a very interesting memoir by H. Berghaus in Algem. Länderkunde, t. xi. p. 357.

[2] Baron Humboldt, in his work entitled "Asie Centrale," from the evidence of numerous facts, concludes that the elevation between the Hymalaya and Kuen-lun, the southern and northern bounding chain of Tibet, does not surpass 11,500 feet mean elevation; that it is consequently 1,285 feet lower than the plateau of Lake Titicaca in South America. (See Map of Mountain Chains in South America, No. 5 of this Division.

[3] See Map of the Phenomena of Volcanic Action, No. 7 of this Division.

MOUNTAIN CHAINS IN NORTH AMERICA,

WITH

HUMBOLDT'S PLAN OF THE VOLCANO OF JORULLO,

AND AN ENLARGED

MAP OF THE ISLAND OF TRINIDAD.

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INTRODUCTORY NOTE.

According to Alexander Von Humboldt; to whose labours we are greatly indebted for the materials used in the construction of the accompanying map, all the great elevations of the New World belong to that long chain which, under different denominations, and with frequent interruptions, extends from one of its extremities to the other, following the direction of the western coasts, over a space of upwards of 10,000 miles in length. This, which is by far the longest range of mountains on the surface of the globe, extending to nearly double the length of the Himalaya range, may be divided in the following manner: The Cordillera de los Andes, from the rocky point of the Island Diego Ramirez, south of Cape Horn, to the Peninsula of Panama, 5,000 miles; the mountain system of Central America, from Panama to the Peninsula of Tehuantepec, 1,200 miles; and the North American chain, from the southern border of the Mexican Plateau to Behring Strait, 4,600 miles. On comparing the principal orographical features of North and South America, we find a striking difference in the position of the great mountain chain with reference to the sea. In South America the chain of the Andes runs parallel with, and at a small distance from the coast; whilst in North America, although the principal mountain chain follows the same general direction, it is at such a distance from the sea as to leave space for another chain running parallel with it. But the isolated and subordinate group, which forms the Brazilian Mountains on the eastern side of South America, has a counterpart in the Alleghanies or Apalachian Mountains of North America, which are separated from the principal chain by the great basin of the Mississippi, extending on the north to the basin of the Canadian Lakes, and the shores of the Arctic Ocean.

Nor is the difference of construction less remarkable. In the Southern Hemisphere, the Cordillera is everywhere rent and interrupted by crevices, which resemble open veins not occupied by heterogeneous substances. Though plains exist there of an elevation of from 9,000 to 9,600 feet, as in Quito, and farther northward in the province of Los Pastos, they cannot be compared, in extent, with those of New Spain; they are, properly speaking, longitudinal valleys limited by the two branches of the great Cordillera of the Andes. In Mexico, on the contrary, it is the ridge of the mountains which forms the plateau, and it is the direction of the plateau which determines that of the entire chain.

In Peru the most elevated summits constitute the crest of the Andes. In Mexico, the same summits, less colossal, indeed, but still of an elevation of from 16,000 to 17,500 feet, are either dispersed over the plateau, or ranged according to lines which have no relation, in parallelism, with the direction of the Cordillera. Peru and New Granada present transversal valleys of which the perpendicular depth is sometimes 4,470 feet. It is the existence of these valleys which prevents the inhabitants from travelling otherwise than on horseback or on foot. In Mexico, on the contrary, carriages roll from the capital to Santa-Fe, a distance of 1,500 miles; and throughout all this route, so little is the surface disturbed by lateral valleys, and so uniform and gentle are its declivities, that art has had no considerable difficulties to surmount.

A.—THE CONNECTED SYSTEMS OF THE WESTERN COASTS.

I. THE MOUNTAINS OF CENTRAL AMERICA.

This system, which, as already mentioned, extends over a length of 1,200 miles from the Isthmus of Panama and Darien to the Isthmus of Tehuantepec, west of Lake Nicaragua, forms three distinct groups, several of the valleys between which have, at different periods, been considered suitable for the establishment of canal communication between the Atlantic and Pacific Oceans.[1] Proceeding from south-east to north-west, we find,

1. *The Group of Costa Rica.* On the Isthmus of Panama, the culminating point is 633 feet high, and here only isolated hills of little elevation occur; but under the meridian of the little rivulet Coclet the mountains rise precipitously, and form the Cordillera of Veragua, which, in the meridian of Boca Toro, unites with the Cordillera of Saimanca, and terminates to the westward of Rio Matina. From its being visible at a distance of 120 miles, A. Von Humboldt calculates its height to be at least 9,000 feet. On the western declivity of this chain lies the mine of Tisingal, celebrated for the immense amount of gold which is extracted from it, and which procured for the country in which it is situated the distinctive name of Costa Rica (rich coast).[2] Under the parallel of about 9° 25′ north rises the middle or proper group of Costa Rica, a plateau of little extent, but considerable elevation, which appears to consist of two or three terraces. The town of Cartago lies highest, being nearly 5,000 feet above the level of the sea: next, San Jose, 4,600 feet; Villa Vieja, 4,230 feet; and Alazuela, 3,920 feet high. This table-land, which is surrounded by volcanoes, among which that of Irasu (11,473 feet) is the highest, rises very gently from the west, but falls suddenly on the east towards the coast of the Caribbean Sea; and on this eastern terrace the Alto de Ochomogo is said to attain a still greater elevation than the Volcano of Irasu. This little plateau is united at the Lago Ermoso to a chain, which appears to terminate before reaching Lake Nicaragua, since the volcanoes by which the lake is surrounded on its southern shores are quite isolated.

2. *Group of Honduras and Nicaragua.* This group is separated from the former by the Lake of Nicaragua, and the River S. Juan. The highest point of the peninsula, which is about 20 miles broad, is near the city of Nicaragua, being only 141 feet above the mean level of the sea, and 13 feet above the surface of the lake. On the northern side of the lake, the border of the plateau forming its western limit, rises suddenly to a height of 8,200 feet near the village of Tagusigalpa. On the north this plateau extends to the coast, where at Cape Camaron it is 2,000 feet high, and at the Bay of Truxillo it has an elevation of upwards of 5,000 feet in the Cerro Guaimatero. The whole of the Mosquito shore is very low.

3. *Group of Guatemala.* This group is remarkable for containing, with the exception of the Island of Java, the greatest number of volcanoes which are known to exist on a given space anywhere on the surface of the globe. It occupies the whole western coast of Central America, and a portion of Mexico, extending from the Plain of Comayagua to Tehuantepec. It is a connected plateau frequently intersected by deep valleys, among which that of the Rio Metagua is the most important. The plateau attains a great elevation round the Gulf of Honduras, where Congrehoy Peak rises to a height of 7,482 feet; the Mountains of Omoa, 7,000; and Cucoomb Mountains, near Balize, upwards of 4,000 feet. The town of Old Guatemala, which, however, is not situated on the highest point of the plateau, has, according to Friedrichsthal,[3] an elevation of about 5,000 feet. South from this city the volcano of Agua, according to the same authority, rises to a height of 15,000 feet, forming, if this calculation can be depended upon, the culminating point, not of Guatemala only, but of the entire mountain system of Central America—a distinction to which the volcano of Antigua, somewhat more than 13,000 feet, has hitherto been considered as entitled. Of the remaining volcanoes, which are situated, partly on the south-west border of the plateau, and partly in isolated positions near the coast, we have treated at length in the notes to the Map of Volcanic Phenomena, No. 9. of this division.

4. *System of the Antilles, or West Indian Mountains.* The Columbian Archipelago, or West Indian Islands, form three distinct and essentially different groups, constituting the Great and Little Antilles, and the Bahama Islands. The Little Antilles consist of a series of small but elevated volcanic islands. The Great Antilles, which do not exhibit any signs of volcanic agency, appear to be of primitive formation, with lofty granitic mountains. The Bahama Islands or Lucayos (Spanish, los cayos) forming a singular group of isles, reefs, and quays, are entirely of coral formation; they are generally low and flat, and surrounded by reefs of coral rocks. The summits of the islands in the Little Antilles have the appearance of a continuous chain, but the larger islands are separated by seas of unfathomable depth. The Great Antilles have been considered as the remains of an extensive mountain system broken up by irruptions in the Atlantic Ocean. A great range can still be traced through the Island of Puerto Rico, and the eastern part of Haiti. About longitude 72° west this range rises to a summit in the knot of the Cibao Mountains, to the west of which it separates into two ranges, the southernmost of which stretches to Cape Tiburon in Haiti, and is again prolonged in the Island of Jamaica; while the northern range, leaving Haiti at Cape St. Nicolas, is continued westward through the Island of Cuba. The eastern portion of this range is the highest, and it gradually subsides in proceeding westwards. The culminating point of the Cibao Mountains in Haiti is calculated to be about 8,000 feet in height. In Cuba the Sierra del Cobre (Snake Mountain) probably attains a height of 7,200 feet; and in Jamaica, Coldridge Peak (8,185 feet high), at the eastern extremity of the Blue Mountains, is the culminating point of the entire system of the Antilles.

[1] See those referred to by Numbers on the Chart.

[2] At the mouth of the R. Berbiken, on this coast, Columbus founded the first colony of Europeans on the continent of the New World, in the year 1502.

[3] Journal of Royal Geographical Society, vol. xi., p. 39.

II. THE NORTH AMERICAN CORDILLERA.

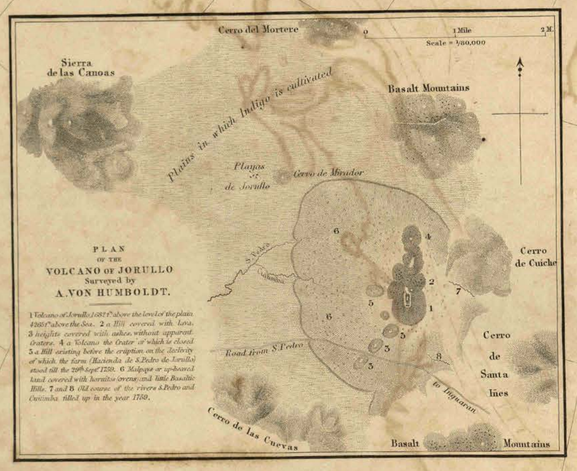
This immense system, which embraces all the mountains of North America situated to the west of the Mississippi and the Mackenzie Rivers, extends, under different names, northward to the 58th parallel of latitude, and probably even to the shores of the Arctic Ocean. At its southern extremity, where it joins the group of Guatemala, it forms a plateau of such amazing extent as to be unequalled on the surface of the globe. This is the

1. *Table-land of Mexico or Anahuac.* The whole vast tract of country between the mountain group of Guatemala in the south, and the Rocky Mountains in the north, consists of the plateau or table-land of Anahuac, which is elevated from 6,000 to 9,000 feet above the level of the sea. Some very high mountains are spread over the surface of the plateau, which is traversed in some places by well-defined ridges, but, as already mentioned, in many directions the surface is quite unbroken, either by hills or depressions. Mexico, the capital, the absolute height of which is more than double that of Snowdon (7,482 feet), is surrounded by four plateaux, namely, the Valley of Toluca, 8,570; the Plain of Tenochtitlan, 7,479; the Plain of Actopan 8,450; and the Valley of Istla, 3,220 feet high. The most remarkable of these plains is that of Tenochtitlan, which is surrounded by ridges of porphyritic and basaltic rocks running in a direction south-south-east and north-north-west. It is of an elliptic form, about 53 miles long, and 35 broad; it is highest on the south-eastern side: and here, towering above the plain, are seen the volcanoes of Popocatepetl, some places by well-defined ridges, but, as already mentioned, in many directions the surface is quite unbroken, either by hills or depressions. Mexico, the capital, the absolute height of which is more than double that of Snowdon (7,482 feet), is surrounded by four plateaux, namely, the Valley of Toluca, 8,570; the Plain of Tenochtitlan, 7,479; the Plain of Actopan 8,450; and the Valley of Istla, 3,220 feet high. The most remarkable of these plains is that of Tenochtitlan, which is surrounded by ridges of porphyritic and basaltic rocks running in a direction south-south-east and north-north-west. It is of an elliptic form, about 53 miles long, and 35 broad; it is highest on the south-eastern side: and here, towering above the plain, are seen the volcanoes of Popocatepetl, 17,720 feet, Istaccihuatl, 15,703, Cofre de Perote, 13,413 feet, and Citlaltepetl or Orizaba,[4] 17,374 feet, above the level of the sea. From Mexico, eastward, in the direction of Vera Cruz, the traveller must proceed over a space of 200 miles before he finds the plateau descend into the valley at an elevation of 3,000 feet, but here it terminates abruptly, sinking at once into the plain. In a westerly direction, on the contrary, the plateau falls gradually with a gentle declivity, so that, at a distance of 60 miles, a similar region is attained as at 200 miles in an opposite direction. The western side of the plateau is also traversed by four longitudinal valleys which rise gradually above one another; these are the Valley of Istla, 3,220 feet; Moscala, 1,693 feet; Popagello, 623 feet; and Peregrina, 324 feet, above the level of the sea. The southern declivity of the plateau is the most irregular; there mountains are seen rising abruptly over one another. Between Mexico and the little towns of Cordova and Orizaba, is situated the group of Popocatepetl, 17,720 feet high, which forms the culminating point of the Mexican system. As already observed, the direction of the Cordillera in the country we have been treating of, is rather indicated by that of the plateau than by the arrangement of the mountains themselves. North from Mexico, near the celebrated mines of Zimapon or El Doctor, the principal chain of the Cordillera assumes the name of Sierra Madre, passing near Guanaxuato, where it presents the richest silver mines in the known world. Proceeding in a north-west direction through Zacatecas and Durango, it passes to the west of Chihuahua; thence advancing in a due north direction, it takes successively the names of Sierra de Azcha, Sierra de los Mimbres, Sierra de los Grullos, and Sierra Verde. To this point the principal chain has been confined to the Mexican territory; continuing its course towards the north, it forms the

2. *Oregon or Rocky Mountains*—a denomination which is sometimes extended as far south as the Sierra Verde. The chain of the Rocky Mountains, after being considerably depressed in latitude 46° and 48°, attains a much greater elevation from latitude 48° to 49°; and continuing in a northerly direction, it separates the affluents of the Saskatchewan and the Mackenzie from those of the Columbia or Oregon, and other rivers which flow towards the Pacific Ocean. These mountains appear to decrease in elevation as they approach the Sierra Madre, and in latitude 42° and 43° they are said to be covered with perpetual snow. The maritime Cordillera, or the

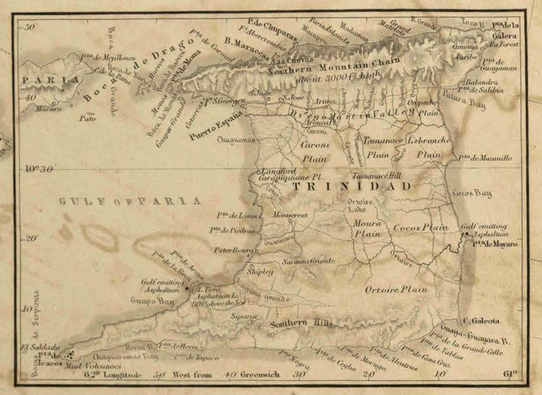
3. *Sea Alps of California, and of the North-west Coast*, is another great chain of the North American system, which is connected with the principal chain by transverse ridges, the best known of which is the chain of the *Snowy Mountains*, which divides the waters of the Colorado, falling into the Gulf of California, from those which join the southern branch of the Columbia, and flow towards the Pacific Ocean. The Snowy Mountains are said to equal the highest part of the Rocky Mountains in elevation; but there is no evidence of this being the case. They approach the latter range near latitude 42° north, in the vicinity of which six great rivers have their origin, and some of the most lofty mountains are situated. The Snowy Mountains appear to be prolonged by the range of the *Black Hills*, which, bearing the central chain of the Rocky Mountains, extend in a north-east direction to the Missouri, with an average height of 1,000 feet. The Sea Alps, but little elevated in the Peninsula of California, increase in height in advancing northwards in Sierra de Lucia and Sierra San Marcos, they then run parallel with the coast, and at a short distance from

[4] For other volcanoes belonging to the Mexican Plateau, see Map No. 9 of this division.



PLAN
OF THE
VOLCANO OF JORULLO
Surveyed by
A. VON HUMBOLDT.

1 Volcano of Jorullo 1683 f. above the level of the plain 4265 f. above the Sea. 2 a Hill covered with lava. 3 heights covered with ashes, without apparent Crature. 4 a Volcano the Crater of which is closed. 5 a Hill existing before the eruption on the Declivity of which the farm Hacienda de S.Pedro de Jorullo stood till the 29th Sept 1759. 6 Malpaque or upheaved land covered with hornito ovens, and little Basaltic Hills. 7 and 8 Old course of the rivers S.Pedro and Cuitimba, filled up in the year 1759.



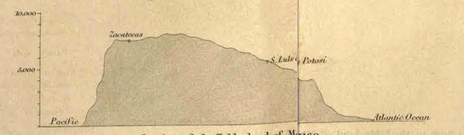
MOUNTAIN CHAINS
IN
NORTH AMERICA.

with HUMBOLDT'S Plan of
THE VOLCANO OF JORULLO
and an enlarged MAP of the Island of
TRINIDAD.
Extended from the Original Designs of
PROFESSOR BERGHAUS, BERLIN.
BY A.K. JOHNSTON, F.R.G.S.

Explanation of the Signs

——— Mountain Chains – – – – Undetermined signs of the same
Slope and Base of Mountainous and Hilly regions
* Culminating & other Summits of Mountain Chains with height in feet
• Volcanoes

All names which have no relation to the Orography are written in light characters thus *Washington.*



Section of the Table-land of Mexico
Between the Parallels of 21° and 23° orth

Parts of the Isthmus of Central America
Suitable for the project of a Canal uniting the two Oceans.

Pacific side	Atlantic side
1 Small Bay of Capira	Rio Naipe & Atrato
2 Gulf of San Miguel or Darien del Sur	Ensenada de Anchucuna
3 Rio de Juan Diaz	Gulf of San Blas
4 Haven of Panama	Rio de Chagres
5 Bay of Chorrera	do do
6 San Juan del Sur	Nicaragua on the Lake of same name
7 Tehuantepec	Coasacoalco

Longitude West from Greenwich

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A.K. Johnston.

it, as far as Mount Olympus, when, passing through the centre of Quadra and Vancouver Island, they appear to join with the Sea Alps of the north-west coast, which continue the range northwards till, at about latitude 60° north, it attains its greatest elevation, and appears to increase greatly in breadth in the territories of Russian America. The southern portion of this chain is called the *Cascade range*, from the numerous rapids and falls occasioned by the passage of the Columbia River in its progress to the sea. The coast range embraces Mount Fairweather, and terminates in Mount St. Elias (17,860 feet), the culminating point of the whole North American system.

B —THE ISOLATED MOUNTAIN GROUPS OF THE EASTERN SIDE OF THE CONTINENT.

1. *The Alleghanies or Apalachian Mountains.*[1] This system, which is a lengthened plateau, crowned with chains of hills, consists chiefly of four separate groups crossing the country in the same general direction, from north-east to south-west, extending from 33° to 41° north latitude, between the mouth of the St. Lawrence and the sources of the Alabama. These parallel chains of mountains are situated on an extensive table-land, nearly in the middle space between the Atlantic Ocean and the Mississippi River, dividing the waters which fall into the former from those which flow to the St. Lawrence on the north and the Mississippi on the west.[2] The different ridges are distinguished from each other, not only in their external features, but also in their geology. They are divided by numerous and extensive longitudinal valleys, which are again intersected by lateral basins. The mean elevation of these mountains is about 2,500 feet. The most remarkable of these is the *Eastern Chain* or the *Blue Mountains*, which extend from Georgia in a north-east direction to the State of New York. These are prolonged northwards by the small group of the *Catskill Mountains* on the right bank of the Hudson; and beyond that river by the *Green Mountains*, which, from the latitude of Quebec, follow nearly the course of the River St. Lawrence, and terminate on the Gulf of the same name, between the Bay of Chaleurs and Gaspé Point. To this chain belongs the group of the *White Mountains*, in which is situated Mount Washington (6,620 feet high), the culminating point of the entire system.

We may regard as geographical dependencies of this system, (1.) The range of mountains which runs in a north-east direction along the northern shores of the Gulf of St. Lawrence, forming undulating ridges, seldom more than 1,000 feet in elevation. (2.) The low range which traverses the whole of Lower Canada and Labrador to Sandwich Bay. The *Mealy Mountains* are the highest on this coast, and have been computed to be about 1,484 feet high.[3] These, as well as the high-land of Kiglapaed, in latitude 57°, are always snow-clad. (3.) The Notchish Mountains between the Gulf of St. Lawrence and Hudson Bay. And, (4.) The Wisconsin Hills between the Mississippi and Lake Michigan.

2. *The Arctic System.* Under this name M. Balbi[4] proposes to include all the mountains already known, or which may yet be discovered in the countries within the Arctic Circle. Very little is known of the orography of this part of the globe; but from the direction of the islands and archipelagoes in Greenland, North Devon, North Georgia, and the Parry Islands, we may infer that of the mountain chains to be from south-east to north-west.

The Arctic Highlands. This region extends from the shore of Hudson Bay, near the mouth of the Churchill River, westward by the eastern extremity of Athabasca Lake, and Great Slave Lake, to the mouth of the Mackenzie River. The eastern portion of this vast tract rises with a steep ascent from the shore; the interior is unknown, but it probably maintains a considerable height to some distance from the coast. In the western districts, where it was traversed by Captain Back, it sinks to a much lower elevation. This quarter is known by the name of the "*Barren Grounds.*" The entire region is nearly destitute of wood, except isolated clumps, which are found on the banks of the large rivers. The whole surface is occupied by low hills with rounded summits and precipitous sides.

C.—SAVANNAHS AND PLAINS.

America contains the most extensive plains in the world. Of these, the vast basin which extends from the mouth of the Mackenzie River in the Arctic Ocean to the delta of the Mississippi, and from the principal chain of the Rocky Mountains to the Alleghanies, embraces an area which, including the valley of the St. Lawrence, is estimated to contain 2,250,000 square miles. This immense tract of country is separated by a low watershed into two great basins, the waters of which flow into the Polar Sea, Hudson Bay, and through the Canadian Lakes and the St. Lawrence, into the Atlantic Ocean; and the southern basin of Missouri-Mississippi, the waters of which fall into the Gulf of Mexico. This southern basin contains those vast grassy plains called *Savannahs* or *Prairies*, which extend on both sides of the Mississippi, but chiefly to the westward of that river. "There are no prairie lands," says Dr. Richardson, "north of the Peace River, and no flat country skirting the Rocky Mountains beyond Great Slave Lake."[5] "The great peculiarities of this region are, huge streams, sunken into narrow valleys, bordered by cliffs and bluffs, alternating with beds of former lakes."[6] At the heads of the Arkansas, Platte, and Yellowstone Rivers, bounded on the north by the Black Hills, and on the west by the Rocky Mountains, a large tract covered with sand and gravel has received the name of the *American Desert*. This tract is not destitute of vegetation, but produces a sufficient number of hardy plants to serve for the support of large herds of buffaloes.

PLAN OF THE VOLCANO OF JORULLO.

As shown in the Map of the Distribution of Volcanos over the Globe (No. 7 of this division), the Volcano of Jorullo is situated within the volcanic series of Mexico, in latitude 19° 29′ north, longitude 101° 01′ 45″ west. The great catastrophe which caused the upheaval of this mountain from the surface of the earth, and through which a country of considerable extent totally changed its appearance, is perhaps one of the most extraordinary physical revolutions which the annals of the history of our planet present. Geology describes the shores of the ocean, where, up to recent times, during a course of two thousand years, were the Azores, in the Zigean Sea, and at the south of Iceland, volcanic isles have elevated themselves above the surface of the water; but it presents no other example where, in the interior of a continent, at a distance of thirty-six leagues from the shores of the ocean, and more than forty-two leagues from any other active volcano, there was formed suddenly, in the centre of a profusion of little burning cones, a mountain of scoriæ and ashes to a height of nearly 1,700 feet above the former level of the neighbouring plains.

In order to explain the accompanying plan, it is necessary to enter into greater detail than is usually given in geological treatises; and to accomplish this we shall quote further, and nearly in his own words, the description of the illustrious traveller who first made its existence known in Europe.[7]

The Plain of Malpays (1 and 2 on the plan), on which the volcano is situated, forms a part of an elevated plateau, from 2,000 to 3,000 feet above the level of the sea. Until the middle of the eighteenth century, fields in which the sugar cane and indigo were cultivated extended between the two rivulets called Cuitimba and San Pedro (7 and 8 on the plan). They were bounded by basaltic mountains, the structure of which clearly indicated that at a remote period the whole country had been the theatre of volcanic action. These fields, watered artificially, belonged to the plantation (*Hacienda*) of San Pedro de Jorullo, one of the richest regions of the country. In the month of June 1759, a subterranean noise was heard; frightful bellowings (*bramidos*) were accompanied by frequent earthquakes, which succeeded each other during fifty or sixty days, and threw the inhabitants of the Hacienda into the greatest consternation. From the commencement of the month of September the subterranean noise seemed to be restored, when in the night, between the 28th and 29th of the same month, a dreadful subterranean concussion was again observed. The terrified Indians sought for safety on the Mountains of Aguasuco. On this occasion the ground which is called the *Malpays* (marked 6 on the plan), to an extent of from three to four square miles, was raised in the form of a bladder, to a height of 550 feet above the plain at the highest point.[8]

The Malpays, towards its sides, has an elevation of only forty feet above the level of the former plain, called *los Playas de Jorullo*, but the convexity of the upheaved soil rises progressively towards the centre, to a height of 525 feet. Those who, from the summit of Aguasuco, witnessed this great catastrophe, assert that flames were seen to burst from the ground over an extent of more than half a league square; that fragments of incandescent rocks were thrown to a prodigious height; and that across a thick cloud of ashes, lighted up by the volcanic fire, it appeared as if the softened crust of the earth were swelling. Then the rivers Cuitimba and San Pedro were precipitated into the burning crevices. The decomposition of the water contributed to revive the flames, which were distinguished at the town of Pascuaro, although situated on a broad plateau, and elevated 4,500 feet above the plains of *los Playas de Jorullo*. Eruptions of mud, and especially of beds of clay, in which balls of decomposed basalt were enveloped, seemed to indicate that subterranean waters had played a most important part in this extraordinary revolution. Thousands of little cones, from six to ten feet in height, termed by the natives ovens (*hornitos*) arose upon the upraised vault of the *Malpays*. Each little cone was a *fumarole*, from which a dense smoke ascended to a height of from thirty to fifty feet. In many of these cones a subterranean noise was heard, which appeared to indicate the proximity of a fluid in a state of ebullition. In the middle of these *hornitos* six volcanic cones were formed upon a chasm, in a direction from north-north-east to south-south-west, each elevated from 1,300 to 1,600 feet above the level of the former plain. The highest of these enormous cones is the great volcano of Jorullo, 1,682 feet above the level of the plain, and 4,265 feet above the sea. Great eruptions of the central volcano continued till the month of February 1760, but in succeeding years they have become progressively more rare. The Indians, frightened by the dreadful turmoil caused by the new volcano, at first abandoned the villages situated at a distance of seven or eight leagues from the *Playas de Jorullo*; but in a few months they became accustomed to the frightful spectacle, and returning to their cabins, they descended towards the mountains of Aguasuco and Santa Ines, in order to admire the jets of flame thrown out by an infinity of great and little volcanic mouths. The ashes then covered the roofs of the houses in Queretaro, at a distance of more than forty-eight leagues in a straight line from the place of explosion.

Although, at the time of Humboldt's visit, the subterranean fire appeared to possess but little activity, and the Malpays and the great volcano were beginning to be covered with vegetation, the surrounding air was found to be heated by the action of the little ovens (*hornitos*), that at a distance from the surface, the thermometer rose to 109°.2 in the shade. This fact appears to prove that there was no exaggeration in the testimony of some old Indians, who reported that several years after the first eruption, the Plains of Jorullo, even at a great distance from the upheaved surface, were uninhabitable, in consequence of excessive heat. Near the Cerro of Santa Ines, the rivers Cuitimba and San Pedro (7 and 8 on the plan), whose limpid waters formerly irrigated the fields of sugar cane, are still pointed out. These streams were lost on the night of the 29th September 1759; but further to the west, at a distance of one and a quarter mile, and within the upheaved district, two rivulets were seen bursting the argillaceous crust of the *hornitos*, and presenting themselves as thermal springs, in which the thermometer rose to 128° 8. The Indians preserved in these the names of Cuitimba and San Pedro, because in many parts of the Malpays they thought they could hear the sound of great masses of water flowing in a direction from east to west. It is not ascertained that there has been any eruption of Jorullo since A. Von Humboldt's visit in 1803.[9] When Mr. Burkart examined it in 1827, the *hornitos* had ceased to emit vapour. During the twenty-four years that had intervened between his visit and that of Humboldt, vegetation had made rapid progress on the flanks of the new hills—the rich soil of the surrounding country was once more covered with luxuriant crops of sugar cane and indigo, and there was an abundant growth of natural underwood on all the uncultivated tracts.[10]

THE ISLAND OF TRINIDAD.

In the notes on the Phenomena of Volcanoes, in a preceding sheet (page 2, Map No. 7 of this division), mud volcanoes are incidentally mentioned as contrasted with proper volcanoes, or burning mountains. The Island of Trinidad affords some interesting examples of these minor volcanoes, and as we have found space on this sheet for a map of that island, we shall here continue the subject in so far as may appear to be necessary for its more complete elucidation. "It appears to me," says A. Von Humboldt,[11] that *mud volcanoes* deserve more attention than geologists have been accustomed to give them. The grandeur of this phenomenon has been misunderstood, because, of the two phases of activity and rest which it presents, the last—that is to say, the period of repose, in which mud volcanoes remain for centuries—is the only one on which observations have been made. The appearance of mud volcanoes is accompanied by earthquakes, subterranean thunders, the upheaval of entire countries, and the eruption of flames, which rise to a considerable elevation, but are of short continuance. The mud of these volcanoes is usually cold, but sometimes it is of a high temperature, as at Damak in the Island of Java. The gaseous eruptions, accompanied by noise, are also of different kinds, as hydrogen mixed with naphtha, carbonic acid gas, and even nearly pure azote or nitrogen. After the first eruption accompanied by flames, mud volcanoes present to the observer the picture of an activity of the interior of the earth, feeble, indeed, but uninterrupted, and always gaining ground. The communication with the deep-lying strata, where a high temperature prevails, is soon interrupted, and the eruptions of cold mud show that the seat of the phenomenon, when it has arrived at its second stage—the state of repose—cannot be at a great distance from the surface."

The Island of Trinidad, extending between latitude 8° 20′ and 10° 51′ north, and longitude 60° 30′ and 61° 20′ west, is evidently a section of the opposite continent of South America, from which it has probably been detached by a convulsion of nature, since the same signs of earth, the same rocks, fossils, &c., are common to both. The northern chain of mountains, about 3,000 feet high, is a continuation of the central Cordillera of Venezuela, and like that portion of it which extends through the Peninsula of Paria, is covered to the summit with forest trees. The centre of the island is occupied by a series of low hills and mounds; and in the south a range of hills, none of which exceed 1,000 feet, runs parallel to the shore.

The Asphaltum or Pitch Lake of Trinidad is situated on a peninsula near Punta de la Brea, on the south-western promontory of the island. It is about a mile and a half in circumference, and elevated eighty feet above the level of the sea. The headland on which it is situated consists of bituminous scoriæ, vitrified sand and earth cemented together. In some places beds of cinders are found; and a strong sulphureous smell pervades the ground to the distance of eight or ten miles from the lake.[12] A considerable extent of country in its vicinity is covered with pitch, which runs a long way out to sea, and forms a bank under water.

The pitch at the sides of the lake is perfectly hard and cold, but towards the middle the heat gradually increases, and the pitch becomes softer and softer, until at last it is seen boiling up in a liquid state. Several attempts have been made to ascertain the depth of the lake, but none have ever been found. Science is at a loss to account for this extraordinary phenomenon; for the lake does not seem to occupy the mouth of an exhausted crater, neither is the hill on which it is situated of volcanic origin, for its basis is clay. No eruption has taken place within the memory of man, although the principle of motion still exists in the centre of the lake.[13] Dr. Nugent suggests that the origin of this substance may be owing to the enormous quantities of woody and vegetable matter which the Orinoco has for ages been rolling down to the surrounding sea, which, being arrested by currents and eddies, and subjected to the influence of subterranean fire, undergoes those transformations and chemical changes which produce petroleum, and this being forced up to the surface, forms, by exposure to the air, the different kinds of pitch or asphaltum, as we find it.[14]

Mud Volcanoes. These are situated at Punta de Icacos, the south-western extremity of the island, forty miles south from the Pitch Lake. They occupy a plain elevated four or five feet above the general surface. The largest of these is 150 feet in diameter, and has boiling mud constantly bubbling, but never overflowing, and remaining constantly within the surface of the crater. Some of these volcanoes throw out salt water, loaded with argillaceous earth. "In some of the chimneys this went on slowly, or not at all; in others it might be called a pretty active cold ebullition. The surface of the platform surrounding the chimneys was perfectly firm."[15] During the hottest months of the dry season, the eruptions take place with a noise which is described as being like that of the loudest cannon; then the mud is blown up to a height of at least thirty feet in the air, and the volcano cannot be approached within fifty paces.[16]

Subterranean Volcanoes. South of Punta de la Brea there is a gulf, or vortex, which, in stormy weather, gushes out, raising the water five or six feet, and covering the surface for a considerable space with petroleum or tar.[17]

Near Punta de Mayaro, on the eastern coast of the island, there is another subterranean volcano, which, in the months of March and June, gives several detonations resembling thunder; these are succeeded by flames and smoke, and, some minutes after, pieces of bitumen, as black and brilliant as jet, are thrown on shore.

NOTE ON THE CONSTRUCTION OF THE MAP.

This Map is constructed on the same principle as that of the Mountain Chains in Asia and Europe, (No. 5 of this division), in the notes to which we have stated our reasons for adopting continuous lines as symbols for representing chains of mountains in a great continent. Unfortunately the materials used in constructing this map are very deficient and unsatisfactory, for, except the central part of the country personally visited by the illustrious Humboldt, very little is known of the orography of North America. Even in populous districts this is the case; for although large maps of nearly all the States have been published, in which new counties and townships are carefully inserted, the hills, slopes, and valleys are generally neglected.

The public surveyors of the United States are not required to distinguish mountains and hills, table-lands and plains, or valleys and slopes; consequently it is usual to represent the country as uniformly level, although it may be full of inequalities.[18]

The names by which the several systems are designated are also very confused, different writers often applying the same name to different ranges of mountains. For this reason it is very desirable that the native names should be restored.

M. Balbi proposes to class all the mountains of the New World into eight systems, of which three belong to the continent of South America, two to that of North America, and one to each of the three Archipelagoes—one of which is situated at the east of the central part of the continent, and one at each of its extremities. As the proposed names of these systems are founded on the great physical features of the country, they appear to be worthy of general adoption.

[1] They are called the Apalachian Mountains, to the south of the Potomac, and Alleghanies to the north of that river. It has been proposed to designate them by the more appropriate name of the Atlantic System.

[2] The celebrated height of this plateau, according to M. Balbi, who states it as the result of heighmend research, is from 1,130 to 3,300 toises.

[3] Journal Royal Geographical Society, vol. iv., p. 208.

[4] Abrégé de Géographie, third edition. Paris, 1834.

[5] Appendix, Captain Back's Journal, p. 657.

[6] Journal Royal Geographical Society, vol. iii., p. 163.

[7] Essai Politique sur le Royaume de la Nouvelle—Espagne, tome i., p. 391 &c.

[8] De Beroja suggests that this phenomenon may be more naturally accounted for by supposing that the lava, flowing from different centres, and chiefly from Jorullo, united into a sort of pool or lake. That being poured out on a surface previously flat, it would, if not very liquid, remain deposed near the source, and diminish thence towards the circumference of the space it occupied.

The mountains of North America are thus divided into

I. The MISSOURI-MEXICAN SYSTEM, the principal chain of which embraces the Cordilleras of *Veragua*, *Guatemala*, and *Mexico*, and the Rocky Mountains—for which vague and inappropriate name he proposes to substitute that of the *Missouri-Columbian* Cordillera. The secondary chain comprises the group of the *Ozark Mountains*, the *Maritime Cordillera*, and the Archipelago of the *Aleutian Islands*.

II. The ALLEGHANIAN SYSTEM, embracing the chain commonly known by this name, and which in the south is called the *Apalachians* and the *Pennsylvanik* Mountains; the *Blue* Mountains; the *Catskill*, the *Green*, and the *White* Mountains, in the east, as well as the *Cumberland* Mountains in the west; and, as dependencies of these, the highlands of Labrador, the hilly region of Upper and Lower Canada, and the part of the region of the *Mackenzie-Saskatchewan*, situated to the east of the Mackenzie River and Lake Winnipeg, as well as the *Wisconsin Hills*, and the hills in the Archipelago of the St. Lawrence.

III. The ARCTIC SYSTEM, under which title it is proposed to comprehend all the mountains already known, or which may yet be discovered in the archipelagoes and groups of islands forming the *Arctic Regions*, the principal of which are the groups of *Greenland*, *North Devon*, *North Georgia*, the Archipelago of *Baffin-Perry*, *Iceland*, and the Island of *Jan Mayen*.

[9] Further suppose that fresh supplies were emitted successively during the course of an eruption which lasted more than six months; and that some of these, resting on the first emitted, might only spread to a small distance from the foot of the cone, where they would necessarily accumulate to a great height.—*Bouge on Volcanoes*, p. 267; and *Lyell's Principles of Geology*, sixth edition, vol. ii., p. 261.

[10] Leonhard and Bronn's Neues Jahrbuch, 1835, p. 36, as quoted by Mr. Lyell.

[11] Essai, tome i., p. 232.

[12] Martin's British Colonies.

[13] Sir J. E. Alexander, in Martin's British Colonies, West Indies, vol. i., p. 103.

[14] Geological Transactions, vol. i., p. 67.

[15] Mr. Fergusson in Martin's British Colonies, West Indies, vol. i., p. 107.

[16] Geological Transactions, vol. i., p. 68.

[17] See remarks on the Physical Geography of North America, by C. S. Rafinesque, Journal Royal Geographical Society, vol. iii., p. 165.

[18] See remarks on the Physical Geography of North America, by C. S. Rafinesque, Journal Royal Geographical Society, vol. iii., p. 165.

MOUNTAIN CHAINS IN SOUTH AMERICA,

WITH SPECIAL MAPS OF THE

BOLIVIAN ANDES AND THE TABLE-LAND OF QUITO.

INTRODUCTORY NOTE.

In the construction of this map, the principal materials have been drawn from Humboldt's masterly representation of the mountain systems of the New World.[1] To this have been added, for the Bolivian Andes, the valuable researches of Pentland; and in the small map, the still more recent observations of Alcide D'Orbigny and Morits Bach. The representation of the system of the Parime, or mountains of Guayana, is based on the explorations of Schomburgk; while, for the description of the Andes of Chile and Patagonia, we are indebted to the recent labours of Mr. Darwin.

The highlands of Quito having become, through La Condamine's measurement of a degree of longitude, and Humboldt's travels, "classic ground" in the history of the geographical and physical sciences, it was thought desirable to give a special representation of this part of the Andes. The small map on the lower margin of the plate has therefore been constructed according to that of D'Anville, based on the works of La Condamine, Don Pedro Maldonado, Don Jorge Juan, and Don Antonio de Ulloa, with constant reference to Humboldt's measurements.

In the notes to the preceding map (No. 4 of this division), it is stated that the portion of the great mountain chain of America, designated as the "Cordillera de los Andes," extends from the southern part of the continent to the isthmus of Panama, over a space of 5,000 miles; but, strictly speaking, this designation is confined to the portion south of the equator, since, to the north of that line, the name Andes is unknown in the country.

The Andes of South America is the longest mountain system on the globe, forming an unbroken chain from the one extremity of the country to the other, and differing from the system of the Himalaya, which, considered in its greatest extent, is often interrupted by great river courses and broad valleys, sometimes losing its mountainous character altogether, and extending in the form of a plateau, as in the table-land of Iran.

The great mountain chain of the western, differs from its rival in the eastern hemisphere, especially in this, that its east, throughout its entire length, rises at once from a very low level, so that on the one side its base lies on the sea-shore, and on the other, in a plain, very little elevated above the level of the ocean.

The Cordillera of the Andes was, till of late years, considered the highest range, and one of its summits, Chimborazo, the highest mountain on the globe. But the Cordillera has lost this distinction, since the giant heights of the Himalaya have become known; and Pentland has proved it not even nearly the highest summit of the range. Yet, although the Andes must now take the second rank among the mountain systems of the globe, the numerous volcanic vents which it bears on its surface invest it with an interest totally unknown to the mountains of India.[2]

In the physical formation of the Cordilleras, the most remarkable phenomenon is their splitting occasionally into two or even three parallel chains, which again unite in mountain knots, and enclose great longitudinal valleys, forming true table-lands or plateaux. These appearances are less decided in the Himalaya, from which the plateau of Tibet must be excluded, since it lies beyond the summit of the range, and belongs to the great table-land of Inner Asia.

A.—CONNECTED SYSTEM OF THE WESTERN COAST.

CORDILLERA DE LOS ANDES.

From the extreme southern point of the continent of America, about lat. 54° S., to the parallel of 50° S., where the coast-line trends to the N.N.W., the Andes forms a single chain, which may be divided into two parts, each possessing a character peculiar to itself. The line of separation lies about the parallel of 41° 30′ S. To the south of this is the Patagonian chain, in the vicinity of the coast, which rises to a height of from about 3,000 to 8,000 feet above the level of the sea. It is thickly wooded, and its precipitous summits are covered with perpetual snow, from which glaciers descend almost to the sea-shore. Among the chief of these snowy mountains are the nevados of Mara (lat. 47° S.); Mollmoyo, 7,400 feet high; Yanalico, 8,000 feet; Corcobado, 7,510 feet; Minchinmadom, 8,000 feet; and Yate or Lebecan (lat 41° 45′ S). Narrow gulfs, resembling the fiords of Norway, occupy the deepest valleys of the Andes; and considerable portions of land are detached from the coast, in the form of peninsulas or islands. To the south of lat. 44° 30′, the coast loses its fragmentary character, and the Cordillera, which here forms the commencement of the Andes of Chile, recedes from the ocean, or rather the latter has been more fully developed by volcanic action, so that from this point to the strait of Panama, the Andes leave sometimes a broader and sometimes a narrower strand, over which the mountains sink in terraces towards the sea. As the snow-line falls in this division of the chain, the volcano of Osorno rises to a height of 7,550 feet. Antuco, 12,000 feet, and Aconcagua, 23,200 feet high, also belong to this division. Under the parallel of lat. 32° S., the snow line rises to 12,700 feet; seven degrees further south, in the parallel of Valdivia, it sinks to 8,300 feet; and six degrees further north, in the parallel of Copiapo, it rises to at least 18,000 feet.

Between the parallels of lat. 39° and 18° S., that is, between Valparaiso and Arica, the chain of the Andes is supported on the east side by the remarkable contrefors, formed by the Sierra de Cordova, the Sierra de Salta, and the Sierra Nevada de Cochabamba. The Sierra de Cordova, lat. 32° and 34° S., is the southernmost offshoot of the chain, extending in the direction of the pampas to long. 62° W. The second cross range is the Sierra de Salta and Jugay, which attains its greatest breadth under lat. 23° S., and extends gradually from the valley of Catamarca and San Miguel del Tucuman towards the Rio Vermejo in long. 62° W. The third, and most elevated of all, the Sierra Nevada de Cochabamba and de Santa Cruz, between the parallels of lat. 20° and 17° 20′ S. abuts on the mountain knot of Porco and Potosi. It occupies the Bolivian provinces of Cochabamba and Chuquisaca, as well as part of the provinces of Potosi and Santa Cruz de la Sierra, and forms the water-shed between the tributaries of the rivers Amazon and La Plata. The two cross ranges of Cordova and Salta, of inconsiderable little elevation, attached to the Andes of Chile. The contrefort of Cochabamba, on the contrary, reaches the limit of perpetual snow, which is here about 17,000 feet in elevation, and forms also a side branch of the Cordillera, extending from its crest between Tres Cruces and La Paz. The eastern Cordillera of Tiuriza, to the north, above the rich valley of Cochabamba, rises considerably above the snow line. After sending out the two first cross branches towards the east, the principal chain of the Andes separates for the first time into two great longitudinal ridges near the city of Potosi (lat. 19° 35′). These ridges run parallel with each other, enclosing the immense longitudinal valley or plateau of the great lake of Titicaca, and forming with the high land of Bolivia, which lies between them, the most elevated part of the Cordillera of South America.

Pentland[3] remarks, that in a mountain system formed on the gigantic scale of the Andes, it is difficult to fix the geographical position of each bifurcation, and consequently to state with accuracy the exact parallel of latitude where the Cordillera separates into the two longitudinal ridges of the Bolivian Andes. Yet the western ridge, or Cordillera of the coast, may be said to detach itself from that of the interior in lat. 20° S., in the mountains of Lipez and Chichas, where the road from Atacama, and from the port of Cobija to Oruro (lat. 17° 58′) and La Paz (lat. 16° 30′), crosses the western Cordillera near its southern extremity, and where some snowy peaks rise upon it, the elevation of which can fall little below 18,000 feet. Between the parallels of 19° 20′ and 18°, the western Cordillera attains a very great elevation, and several snow-capped peaks, which rise from the coast-range, overlook the port of Cobija to Arica. The southernmost group of these peaks consists of four majestic nevados, which may be seen from the valley of the Desaguadero on the one side, and from the shores of the Pacific on the other, towering over the port of Iquique (lat. 20° 12′). The nevado of Guallatiri, the most southerly of the group, is the highest of the four, rises from an extensive table-land of new red sandstone, above the alpine village of Cosapa, in the form of a regular truncated cone, enveloped to its base in perpetual snow. Masses of ashes and vapour issue from its summit at intervals, so as to leave no doubt of its being an active volcano. From a trigonometrical measurement, its highest point appeared elevated 4,800 feet above the snow line in March; and as this line seldom descends lower than 17,000 feet in this parallel (lat. 19° S.), in South America, we may conclude that the volcano of Guallatiri rises to an absolute elevation of 22,000 feet. North of Gualatiri rise two magnificent nevados, known to the Creole inhabitants by the name of Medizos or twins, and called Chungara and Parinacota by the Indians. The northernmost of these forms a perfect truncated cone, whilst the northernmost resembles a dome or bell. There is little reason to doubt that the latter has been formed by one great trachytic elevation. The fourth in the group, the nevado of Sayacha to the north, does not appear to exceed 18,500 feet. It forms a rugged ridge of considerable length, in the direction of the axis of the Cordillera, and appears to be also of trachytic origin.

Farther north, between the parallels of 18° 51′ and 17° 30′ S., are several snow-capped peaks, the centre of which may be fixed near the Indian hamlet of Tajora (lat. 17° 50′), and the Gualillas Pass, which attains an elevation of 14,830 feet, where it is crossed by the great commercial road from the port of Arica to La Paz and the interior of Bolivia. The nevado of Chipicani consists of a broken-down crater, with an active solfatara in its interior, emitting quantities of sulphurous and sulphuric acid, which, by their condensation, give rise to the Rio Azufrado. The nevado of Chipicani rises to an elevation of 16,398 feet, which may be considered as the mean height of the snow-capped mountains that belong to this group. To the north of this group, the coast Cordillera is not well known; but in lat. 16° 24′ S., three snow-capped mountains, nearly of equal height, form over the city of Arequipa a group that are Picho-Picho, the volcano of Arequipa or Guagua-Putina, and Chacani. The first and third of these mountains form two elongated serrated ridges; whilst the second presents a very regular volcanic cone, truncated at its summit, and rising to an elevation of 18,300 feet above the level of the Pacific. The three nevados of Arequipa, like the snowy mountains of the western Cordillera south of Arequipa, rise near its maritime declivity; but about ten leagues from the same point, in a south-east direction, and consequently farther removed from the borders of the sea, is situated the volcano of Uvinos, now extinct, which is about 16,000 feet in elevation. On the prolongation of the western Cordillera south of Arequipa rise the nevados of Ambato and Corpuna; and about twenty miles from the same city the colossal nevados of Cimpuihambu, an immense trachytic dome, which has pierced the subjacent strata of new red sandstone, and elevated itself to a height of 21,000 feet. The breadth of the coast Cordillera amounts, on an average, to nearly 100 miles. Since its highest summits are placed on the side nearest the sea, the western declivities of the Cordillera are extremely shelving and steep; so that in many places, the traveller in the course of a few hours, passes from the fruitful valleys on the shores of the Pacific, to the desert regions of the Cordillera, at a height of more than 15,000 feet. On the east side of the coast Cordillera the declivity is less steep, since from the valley of Arequipa to the valley itself elevated 15,000 feet, and from the highest passes the descent is only 4,000 feet to reach the valley of the Desguadero or the shores of lake Titicaca.

The eastern Cordillera detaches itself as a separate chain in the parallel of lat. 20° S.; south of Porco (19° 50′) and of Potosi (19° 35′). The metalliferous mountains which surround Porco may be considered as constituting its southern extremity; and the celebrated mountain, or cerro of Potosi also belongs to it. The mean elevation of this metalliferous group does not exceed 16,000 feet, which is nearly that of the Cerro de Potosi (16,040); none of its peaks consequently rise within the limits of perpetual snow. Between the parallel of Potosi (lat. 19° 35′), and that of 16° 50′, no part of the Bolivian Cordillera attains an elevation of 17,000 feet, none being enveloped in snow during the entire year, until it reaches the latitude of 16° 40′, where the gigantic mass of Illimani suddenly rises, forming the southern extremity of the great Bolivian snowy range. Between Potosi and Illimani, the eastern Cordillera presents numerous passes or cols, some of which equal in height those of the western Cordillera.

[1] Esquisse d'un Tableau Géographique de l'Amérique Méridionale. Relation Historique, tome 2.

[2] See Map of the Pleiocæne of Volcanic Action, No. 7 of this division.

[3] Journal, Roy. Geog. Soc., vol. v. p. 74.

The nevado of Illimani is situated in lat. 16° 46′. Its form is that of a serrated ridge, elongated in the direction of the axis of the chain upon which it rises, offering four principal peaks to the observer, when seen from its western side. From the city of La Paz, distant about thirty miles, it presents itself with the imposing grandeur of Mont Blanc, when seen from the Sallanches, or of Monte Rosa, from the adjacent valley of Maraguaga. The elevation of this giant of the Bolivian Cordilleras is 24,200 feet, and the lowest glaciers on its northern declivity do not descend below 16,500 feet. North of Illimani, but separated from it by the deep valley of Totoraspampa and Tocoral, which forms one of the most frequented communications between La Paz and the province of Yungas, celebrated for its rich plantations of coca, is situated the nevado of Tres Cruces, towering over the Indian hamlet of Totoraspampa; and from this point (lat. 16° 35′) the Bolivian Cordillera may be said to form an almost continuous line of snowy mountains with the western Cordillera in the province of Carabaya, and the mountain knot of Cuzco. To this part of the Andes the denomination of Cordillera Real has been more particularly applied, doubtless from its great elevation and grandeur. The most elevated pinnacles of this snow-capped chain rise over the large Indian village of Sorata, in the province of Larecaja, and hence are known among the Creole inhabitants by the name of Nevado di Sorata, and by the Aborigines by the several names of Ancomani, Itampe, and Illimpupa; the most elevated (lat. 15° 48′) attains the immense height of 25,250 feet, being the highest point in America. When seen from its western declivity, the Bolivian Cordillera offers a succession of sharp, rugged peaks, and serrated ridges, in a configuration which contrasts with the conical and bell-shaped summits of the Cordillera of the coast, and results from their different geological composition.

The passes which traverse the eastern Cordillera south of Illimani, are situated at elevations exceeding 14,000 feet. In this portion of the chain no part descends below this level; and the rivers, consequently, that rise on its western side, empty themselves into the Desguadero. Arrived, however, at the snowy portion of the range, things become completely changed, and the torrents which there descend from either declivity of it empty themselves invariably into the affluents of the Amazon; those on the west side crossing the chain of the Bolivian Cordillera, whence it arises that the snowy Cordillera is traversed south of lat. 16° 50′ by many deep valleys, and offers many passes at elevations greatly inferior to what might at first view be expected from the exclusive mean elevation of its highest summits. This very remarkable fact of rivers passing through such an immense mountain-mass as the Bolivian Cordillera, is perhaps one of the most important points connected with the physical geography of this portion of the Andes. The depression is so considerable, that the valley in which the Rio Chuquapajo, which waters the city of La Paz, breaks through the chain, does not probably exceed 6,000 feet; and thus we have a valley 18,000 feet lower than the neighbouring peaks (those of Illimani) which almost overhang it—perhaps the greatest differences that has been observed in the level of the most elevated points, and of the adjoining valleys of any mountain system yet examined. The declivity of the Bolivian Cordillera is rapid on either side, but particularly so on the east. On the west it presents elevated transverse valleys, whilst on the east it sends off many lateral ridges, which form the contrefort of Cochabamba.

The longitudinal valley bounded by the coast and interior Cordillera, is remarkable, not only for its great size, but especially from its extraordinary height. "The existence of a table-land, the superficial area of which is calculated to exceed 16,000 geographical square miles, and of which one-fourth or one-fifth is occupied by a lake, situated 12,795 feet above the level of the sea, is undoubtedly a very remarkable geological phenomenon." The interest is further increased by the fact, that this plateau is the centre of civilization, occupied by many rich cities, and a numerous population. The lake of Titicaca occupies an area of about 4,000 geographical square miles, being about twenty times larger than the lake of Geneva. It receives numerous streams at its northern extremity, but by no means so great a mass of water as might be expected from the height of the Andes that surround it; arising from the *diversia aquarum* of the two Cordillere chains distant from the shores of the lake, so that the greater part of its waters run towards the Pacific, while on its eastern side the lake is bordered by a low secondary ridge of red sandstone, which prevents the torrents descending from the eastern Cordillera reaching it, and causes them to form the Lagos of Aspiri and Chiquiapo, running to the Amazon.

The Lake of Titicaca, or Laguno de Puno, contains numerous small islands: the largest and most celebrated of which, and from which it takes its name, is situated at the south-eastern extremity.

The plateau of Bolivia, as the great longitudinal valley of Titicaca and Desaguadero may be called, is intersected in the centre by a series of elevations, in a direction from south-east to north-west, connecting the western with the eastern Cordillera. No part of this ridge reaches the limits of snow; its most elevated point, situated between Corocoro and La Paz, and composed of new red sandstone, rises to an elevation of 15,100 feet. Mr. Pentland calculates the breadth of the Bolivian Andes as follows:—

			Miles.
Between lat. 16° and 17° south,			199·5
,,	17	18	214·5
,,	18	19	230·0
,,	19	20	260·0

But, including the lateral ridges which rise from either side of the Andes, in the parallel of 17° 20′, in which the town of Santa Cruz de la Sierra is situated, the mountainous ridges which rise from the two Cordilleras, and these two Cordilleras themselves united, occupy an extent of 300 geographical miles.

The junction between the Cordillera Real and the coast Cordillera, occurs between lat. 14° and 15° S. In the mountains of Cuzco, the greatest in the whole chain of the Andes, comprising the mountains of Vilcanota, Carabaya, Allanzay, Humbolo, Parinacochas, and Andahuallas, and having numerous snowy peaks, which rival those of Chimborazo.

Beyond this knot there is another double chain on the east and west of the Rio Jauja. The eastern chain extends from the mountain knot of Cuzco, and the western of the Cuntesuyus and Yauli. The plateau enclosed by these chains is about one-half shorter than that of Bolivia. Two snow-capped mountains, which are seen from Lima, and called Tolde de la Nieve, belong to the western Cordillera.

In the north-west of the valley of Sahcahuaba, between 11, and 10° S., the two chains of the Jauja plateau unite with the mountain knots of Huanuco and Pasco. In this part of the Andes, the mountains of colossal height, the nevados of Sanguanuen and La Viuda, which are visible at Huanuco. The plateau of these mountain knots appears to be more than 11,000 feet above the level of the sea; whilst the nevados of Viuda attain the height of nearly 16,000 feet. At this point the Andes divide into three chains, the easternmost of which rises between the Rio Huallaga and the Pachitea; the second or middle chain is situated between the Huallaga and the Upper Marañon; and the third or western, between the Upper Marañon and the coast of Truxillo and Payta.

The Andes of Huanuco run N.N.E., where it is bordered by the pampas of Sacramento, it then turns N.N.W, and sinks in about lat. 5° 30′ S. It appears to unite with the middle chain south from Pucuyacu, and west from Chacopoyas, under lat. 6° S. North from Pucuyacu, the central chain sends out two branches towards La Vellora and San Borja, the second of which forms the celebrated pongo (waterfall) of Manseriche. In this zone, between lat. 10° and 5° S., neither the eastern nor the middle chains have any summits which reach the snow line; these are confined to the western chain. The central chain hardly reaches the height of 10,000 feet, and it sinks gradually on the north side, to 5,000 feet.

Beyond the Rio Huallaga and the Pachites there are on the east only groups of low hills. The western chain, which is the highest, runs nearly parallel with the coast line in the direction of N. 27° W. It presents, between lat. 9° and 7° 30′, the three nevados of Pelagatos, Moyopata, and Huayllias. The last of these is the most remarkable, since it is the only snow-capped mountain along the whole chain northwards to Chimborazo.

The Upper Marañon crosses the western part of the longitudinal valley, which is limited by the Cordilleras of Chacapoyas and Caxamarca. If this valley be considered as connected with that of the Rio Jauja, it will be found to form an immense basin of 440 miles in length. The two alpine lakes of Lauricocha and Chinchycocha, in which the Amazon and the Rio Jauja originate, lie on the south and south sides of this rocky plateau, which is formed by an extension of the knots of Huanuco and Pasco.

Between the mountain knots of Cuzco and Loxa (lat. 4° to lat. 5° S.), the chain of the Andes extends to an extraordinary breadth. Along the whole eastern chain from La Paz to Huanuco (lat. 17° 20′ to 19° 20′), a broad hilly terrace extends and occupies the space between the Beni and the Pachiten. The chain between the Uruyali and the Huallaga terminates about the parallel of lat. 5° 20′, and joins with that of Chacapoyas or the middle chain, which, farther south, stretches N.N.W., and abuts against the western chain, where it contributes to form the great mountain knot of Loxa, which has a mean height of only from 6,400 to 8,300 feet. It occupies the space from lat. 5° 30′ to 3° 30′ S., and some of its peaks are from 10,000 to 11,000 feet high. Towards the east the mountains sink very abruptly, to an elevation of from 5,200, to 4,000 feet absolute height. North of Loxa in lat. 3° 20′ S.

BOLIVIA
according to
Alcide d'Orbigny and Moritz Bach.
1836. 1837.

Section of the Tableland of Quito

Section of the Table land of Bolivia

THE TABLE LAND of QUITO

MOUNTAIN CHAINS
OF
SOUTH AMERICA

ACCORDING TO HUMBOLDT, PENTLAND, ESCHWEGE, D'ORBIGNY, BACH &c.

Extended from the Original Designs of
PROFESSOR BERGHAUS, BERLIN.
BY A.K. JOHNSTON, F.R.G.S.

Geographical Miles 60 to a Degree
100 50 0 300 400 500 600

English Miles 69 to a Degree
100 50 0 200 300 400 500 600

Explanation of the characters used in the body of the Map

Mountain Chains, The broader the line as much greater is the height indicated. Undetermined ejins of the same, Slope and Base of the Mountainous and Hilly regions. Culminating points of the great mountain systems. Culminating points of Simple Chains, Mountain knots. The figures give heights in English Feet.
All the names which have no relation to the Orography are expressed in light letters thus PERU Mountains.

Long. W. Greenwich

Engraved by W. & A.K. Johnston

William Blackwood & Sons, Edinburgh & London.

the mountain knot divides into two branches, enclosing the longitudinal valley of Cuenca; but under the parallel of 2° 27′, these again unite in the mountain knot of Assuay, a trachyte group, the plateau of which, at Cuellaf, is situated at a height of 15,500 feet, being near the limits of the snow line. Between the parallels of 2° 30′ and 9° 40′ S., another division of the chain occurs. The western chain being that of Chimborazo (21,420 feet) and Carguairazo; the eastern that of the volcanoes of Sangay, Collanes, and Llanganate. North from the latter, in lat. 0° 40′ S. between the summits of Iliniza (17,377 feet high), and Cotopaxi (18,880 feet), lies the mountain knot of Chisinche, a sort of narrow dyke, which forms the water-shed between the Atlantic and Pacific Oceans. The Alto de Chisinche is only 300 feet above the surrounding plateau. Beyond the knot of Chisinche the chain again separates, and extends from 0° 40′ S., to 0° 20′ N. latitude; that is, to the volcano of Imbabura, near the ville of Ibarra.

On the eastern Cordillera, are the snow-clad summits of Antisana (19,137 feet high), Gauxaui, Cayambe (19,617 feet), and Imbabura; on the western Atacazo, Pichincha (15,922), and Cotacache. In the valley between these chains (which, as already remarked, may be considered as "chains par excellence" of the astronomy of the eighteenth century) are the hills of Ichimbio and Puignasi, on the east side of which lie the plateaux of Puembo and Chillo; and, on the west those of Quito, Inaquito, and Turubamba.

Nowhere in the Cordillera of the Andes, are so many great mountains assembled together, as on the east and west of this great basin of the Republic of Ecuador, in the portion extending from lat. 1° 50′ S. to 0° 15′ N. of the equator. This basin terminates on the south in the knot of Loxa; and on the north in the plateau of Los Pastos. (See the Section of the highlands of Quito, on left margin of the map.)

In this province, between the snowy peaks of Cotacache and Imbabura, the two Cordilleras of Quito unite in a single mass, extending from lat. 0° 21′ to 1° 13′ N. This mass, on which, the volcanoes of Cumbal and Chiles are situated, forms the mountain knot of Los Pastos. The volcano of Pasto (the inhabited plateau of which is more than 10,000 feet above the level of the sea) is situated at the north of this group. This may be called the Tibet of the equinoxial countries of the New World.

North of the city of Pasto, the ridge of the Andes once more divides into two chains, enclosing the plateau of Almaguer. On the slope of the eastern Cordillera, is the Sienaga de Schoshoni, which forms the source of the Putumayo; and the western is broken through by the river Patia. North-east of Pasto is the knot of Puracio de las Papas and Sucobosi, which, in lat. 2° 3′ N., splits into two chains running nearly parallel with each other, as far as lat. 5° N. The easternmost of these is called the chain of Sierra Pari, or the Cordillera of New Granada, or the mountains of Cundinamarca, which stretches in a north-east direction to the Sierra de Merida; the middle range is called the chain of Quindiu or the central chain of New Granada; and the westernmost, the chain of Choco, or the coast chain. To the north of the parallel of lat. 5°, the only summits within the snow line in these Cordilleras belong to the eastern chains, the western declivities of this chain are very precipitous on the ocean side; while, on the west it spreads out into a plateau from 8,200 to 9,000 feet high, on which are situated the cities of Bogota, Tunja, and Neiva.

The central or Quindiu chain extends from the east of Popayan over the plateaux of Malbosa, Huila, Tolleua, &c., to the province of Antioquia. To this chain belongs the peak of Tolima 14,850 feet in elevation, the highest point of the Andes north of the equator. The Choco or coast chain, is, in its whole extent, of little elevation when compared with the central and eastern chains. On its western declivities, is the celebrated gold and platina country, an alluvial zone from thirty to forty miles broad. The culminating point of this chain appears to be the peak of Torra south-east of Nayita. The group of Antioquia may be called a mountain knot, because it connects the middle with the western chain. This group is divided into two great masses, the one between the Rio Magdelena and the Rio Cauca; and the other between the Cauca and the Atrato. Its culminating point is the Alto del Viento, which is only 3,350 feet in elevation. Little has been ascertained as to the connection of this group of Antioquia north of the parallel of lat. 7° N.; it is only known that the mountains trend to the north-west, and that they sink very rapidly. The mountains of the Isthmus of Panama may be considered, from their position, as a continuation of the group of Antioquia and Choco.[1]

B.—COAST CHAIN OF VENEZUELA.

This system, which, from its form and direction, has exercised such an important influence on the cultivation and commerce of Venezuela, has various names in different situations—as, the mountains of Caracas, Bergantin, Barcelona, Cumana, and Paria; all of which, however, refer to the same chain; the northern division of which extends along the coast of the Caribbean Sea. This is a continuation of the chain of Sierra Pari, which, extending over the Sierra de Merida, terminates in an elevated table-land on which the towns of Tocuyo and Barquisimeto are situated, at a height of from 1,900 to 2,200 feet above the level of the sea. The mountain knot of Barquisimeto forms the eastern wall of a great circular depression, of which the Lake of Maracaybo is the centre, and which is bounded on the south and west by the mountains of Merida, Perija, and Ocana. Between Santa Marta, in the province of Venezuela as a connected chain, it is necessary to examine the form and direction of the coast, from the Punta Tucacas (west of Porto Cabello) to the Punta de la Galera, in the island of Trinidad; this with the islands of Testigos, Margarita, Tortuga, and the peninsula of Araya forms a connected system. The northern chain extends, not only of the mountains of Venezuela, but of all the mountains east of the Andes. This is the Silla de Caracas, which attains an elevation of 8,000 feet. The southern, or interior chain, is much lower than the northern, since its highest point, the Sierra de Guayrunna has been ascertained to be only 7,000 feet. In long. 67° 30′ the two chains are united by the mountain knot of Altos de las Cocuyzas, of 7,000 feet in height. In this knot is situated, by the celebrated basin of the Lake of Valencia, and on the east that of Cornoca. The surface of the first of these basins is from 1,400 to 1,600, and that of the second nearly 2,000 feet above the Caribbean Sea.

The mountains of the peninsula of Araya and of Maniquarez, are connected with the southern chain by the knot of Meapire, which is 2,950 feet in elevation. The mountains of Meapire terminate where their chain sinks suddenly to the Rio Azul and the Guarapiche; but, leaving the continent it re-appears on the south coast of Trinidad, the north coast of which is undoubtedly the continuation of the northern chain of Venezuela.[2]

Sierra Nevada de Santa Marta.—This group lies between two diverging branches of the Andes, the chain of Sierra Pari, and the mountains of Panama. It rises abruptly from the middle of the plain which extends from the Gulf of Darien to the lake of Maracaybo. The highest part of the range trends in a direction from north-east to south-west, at the distance of about twenty miles from the coast. The culminating points, El Pichoe and La Horquetta, are, quite separate, from the peak of San Lorenzo, which is only about twelve miles south-east of Santa Marta; all the three summits are above the limits of the snow line; the greatest elevation is estimated at upwards of 12,000 feet. An evidence of the isolated situation of the Sierra Nevada of Santa Marta is found in the hot climate of the tract of country (terras calientes) by which it is surrounded.

The Mountain System of Parime.—This system, which is called also the Highlands of Guayana, separates the plains of the lower Orinoco from those of the Rio Negro and the Amazon. The principal group extends from the parallels of lat. 3° to lat. 8° N., and from the meridians of long. 58° to 68° W.; fully equinoctial from the Rio Negro to the equator, and to the north of the Rio Caroni. The mean direction of the range is north, 85° W., and the separate chains follow, generally, nearly the same direction. It is not a Cordillera, properly speaking, but an irregularly grouped mass of mountains, separated by plains and savannas, and surrounded on the south, west, and north by the Orinoco.

The most northern chain is that of Santa Ioannes, extending south of the Orinoco, and east of the town of Angostura;—it does not much exceed 1,000 feet in elevation. To the south of this, a chain extends from the Orinoco east to the Caroni by the Cerro del Mato, the highest point of which is probably near the source of the Cano de la Torregua. The next chain towards the south is that of Cheripipe, which extends in a south-east direction to Dutch Guayana, forming in its course the rapid of Para.

The chain of Baraguan is celebrated from the "narrows of the Orinoco," from which it takes its name. Next to Baraguan is the chain of Curichcara and Parimei, which has a very rugged appearance, but is surrounded by low plains, extending on the northern banks of the Amazon and Rio Negro. The latter rises abruptly to a height of more than 2,000 feet. The ridge which extends eastwards from this central point, called the chain of the autarnes, is interrupted by the first great cataract of the Orinoco, that of Aturs. About twenty miles south of the Orinoco and the chain of the cataracts, is that of Quitapa, or Mapipure, which forms the bar of the second great cataract. None of the high peaks of this chain occur on the west side of the Orinoco.

The less chain, to the south-west of the Sierra Parime, is separated from that of Mayparu by wooded plains; it is called Pajapo, and forms a curved wall, which extends from the south-west commencement of that range of elevated mountains which for some miles accompanies the right bank of the Orinoco, and forms the south-west border of the mountains of Parime. The phenomenon so often observed, namely, that the highest part of a group of mountains occurs more frequently at its extremities than near its centre, is shown in this chain. The culminating points, Parime, the Duida (8,734 feet, and Maraveua, probably 10,500 feet in elevation, are situated in the southernmost chain, at the foot of which the plains of the Cassiquiare and the Rio Negro begin. These plains, or savannas, which are wooded only in the vicinity of rivers, do not present such uniformity of surface as is observed in the Llanos of the Lower Orinoco, and the Rio Meta, since they are interspersed with low hills and isolated rocks. West of the Rio Negro, towards its source, and those of the Xie and Uapes, lat. 1 to 2° 15′, long. 74° 76° W., there is an undulating plateau, on which, according to Indian tradition, there exists a "lagoon de mer-ral—a lake, the soil surrounding which contains gold. The Rio Negro, as well as the Issiuba, a tributary of the Cassiquiare, rise in a hilly and rocky region, at a distance of five days' march from Maroa. In Marcellino, the natives are acquainted with a Sierra Tunuby, which lies at a distance of about 160 miles west from their village between the Zie and the Iquanos. It is also recorded, that the River Quiquenai, which flows into the Iquana, rises in a mountain called Cuneyuma. This mountain system, which may be called, provisionally, that of the sources of the Rio Negro and Uapes, the vertical point of which, probably, not above 600 or 700 feet, appears to extend southwards to the district of the Rio Xapura, where ledges of rock form the water-falls of the Rio de los Reguelos, and the hills of Gonzalez de Yapuma, and westwards to the banks of the Upper Guaviare. The foregoing particulars of this little known group are abridged from Humboldt's description of the western regions of the Highlands of Guayana, derived partly from his own observations, and partly from the reports of others. For the central regions, we make use of the accounts of Schomburgk, who, thirty-five years after Humboldt, explored the region of Guayana.

In proceeding from the north coast of Guayana, where the rivers Essequibo, Demerara, Berbice, and Corentyn, empty themselves towards the south, the country presents a vast extent of flat alluvial soil, formed by the detritus of these great rivers. The fruitful region extends, between the rivers Berbice and Corentyn, for about fifty miles into the interior, and terminates in a series of hills, seldom more than 300 feet in elevation, which cross the Essequibo in lat. 0° 15′, the Demerara in lat. 6° 5′, and the Berbice in lat. 7° N. At the 6th parallel there is an extension of the mountains of the Orinoco, perhaps a continuation of that chain which forms the rapid of Mara, stretching in a southern direction. Wherever the ridge crosses a river course it forms a great waterfall, as exemplified in the cataracts of Tiwaiwiki and Quoiquoeen in Essequibo, the Imbrom and the Christina cataracts in Berbice, and the great cataracts in Corentyn. Near these waterfalls are the highest points of the chain, viz., the Maueri on the Essequibo, 800 feet above the bed of the stream; the mountains of Imbrom on the Berbice, 820 feet above the river. This chain appears to be connected with the Sierra Acaraï, which lies nearer the equator; and all geological appearances indicate the probability that it was, at one time, surrounded by the Atlantic Ocean.

Under the parallel of lat. 4° N., a second mountain-chain, that of the Pacaraima, extends west-ward from the Essequibo. This is also an extension of the mountains of the Orinoco. The culminating point of this group is Roraima, the highest of a series of sandstone hills in lat. 3° 20′ N., long. 60° 30′ W. This remarkable group extends from north-west to south-east, rising 500 feet above the table-land on which it is situated, or 4,450 feet above the level of the sea. Roraima is, in fact, a perpendicular wall of more than 1,500 feet in height. From the declivities of these mountains numerous streams descend to augment the three greatest river systems of the northern half of South America—the Orinoco and Essequibo on the north, and the Amazon on the south.

Further south, the Mayarapan was considered the highest mountain of central Guayana, but it is now ascertained to be much lower than Roraima, being only about 3,500 feet above the level of the sea. It lies in lat. 3° 59′ N., near the northern bank of the Rupununi, the largest of the south-western tributaries of the Essequibo. To the chain of Pacaraima belongs a conical-shaped hill, resembling the crater of a volcano; and is supposed, that in this part of Guayana there is an active volcano. If this be confirmed, Guayana possesses the easternmost volcano in the New World.

The Canuucu, or Conocou mountains, in lat. 3° 30′ N., probably connect the Pacaraima chain with the Sierra Acaraï, in which the Essequibo as well as the Corentyn has its source. This group, the southernmost of the whole system of Parime, may be called the coastal chain. It does not attain the height of Roraima, its highest point being, apparently, little more than 4,000 feet above the level of the sea.

Between the Demerara and the Corentyn, the savannas extend along the course of the Berbice river nearly to the ocean above. These savannas are bounded on the north by the Sierra Acaraï, and on the south by the Canuucu, Taripona, and Coriswaini mountains; on the east by the thick woods of the Essequibo and isolated hills; and on the west, by the mountains of Moucabchai and the extension of the Orinoco chain. The tortuous course of the river Berbice is generally indicated by rows of trees, with here and there isolated groups like verdant islands, or cases in the middle of the savannas, which elsewhere is covered only with grass. From the geological appearances of this region, there is little doubt that it once formed the bed of a lake, the waters of which having burst its barrier, found an outlet in the Atlantic Ocean. This is unquestionably the site of the celebrated Lake of Parime, and the fabulous "El Dorado," the description of which forms so conspicuous a part in the history of the discovery of the New World. A small lake or marsh still exists, namely, Lake Amuca (in about lat. 3° 59′ N., long. 64° W.), situated at the summit-level of the savanna, on the water-shed between the Essequibo and the Amazon, at an elevation of about 600 feet above the level of the sea. During the dry season it nearly disappears, and is overgrown with reeds; but in the rainy season, it not only fills but overflows its bed, and sends its waters eastward to the Rupununi, and westward to the Rio Branco. With the exception of these savannas, and the marshy flats of the Berbice river, the interior of the high land of Guayana is covered with primitive forests, which display all the magnificence of tropical vegetation.

C.—THE MOUNTAINS OF BRAZIL.

"Brazil," says Eschwege,—the best authority for the description of this part of the New World,—"has nearly the form of a heart, the greatest diameter of which extends, in an east and west direction, from Cape S. Roque in a straight line, over 35° or 40° of long., to that part of Peru where the Amazon quits the Andes and enters the regions of Brazil. A straight line, from Cape S. Roque to the mouth of the Plata, defines the eastern side of this heart, whilst the western extends from the latter to the mouth of the Paraguay, and part of the Madeira, as far as the Amazon. A line drawn from Cape S. Roque, to the embouchure of the Madeira into the Amazon, may be considered as the boundary of the principal northern declivity of Brazil. A range of mountains, the mean height of which may be reckoned at 3,200 feet, extends at a greater or less distance from the coast, on a line from Cape S. Roque to the southern point. Of these only few ranges reach the Cape, and they first become a more prominent character in the parallel of Bahia, lat. 12° 58′ S. From Rio Doce they extend along the bay of Rio de Janeiro south-westwards, behind the island of St°. Catharina. The culminating point Morro dos Canudos, is 4,476 feet in elevation. The northern part of the chain is called Serra dos Aymores, or Vegua Mountains, from the resemblance of its peaks to the tubes of an organ. The southern part is called Serra do Mar, or coast range. Immediately within the coast range commences the Sertão, or table-land of Brazil, which extends from east to west through the whole country. Its mean height may be reckoned at 2,600 feet. From this elevation it sinks gradually in the western regions, towards the Rio Paraguay and Rio Madeira, where it terminates in low swampy plains. It has been erroneously supposed that the highest mountains of Brazil must be found in the province of Matto Grosso, and that they are connected with the Andes of Bolivia. This, however, is far from being the case, since wide extended plains lie between. The sources of the Madeira, which flows north to the Amazon, and those of the Paraguay flowing south to the Plata, are only half-an-hour's distance from each other, and the height of the water-shed is inconsiderable. Both rivers are navigable for small boats to their sources, and the possibility of uniting them by means of a canal has never been called in question. The higher mountains of Brazil extend, generally, like the Andes, in a direction from south to north, and the most elevated, the snowy summits of Corcovado, which the Sierra do Mar, or coast chain of Venezuela, or the Serra of Parime. The different great chains appear to be connected in the interior, and form a ridge whose chief direction is from east to west. This ridge commences at the Serra do Mar, and extends through the provinces of Minas, Goyas and Matto Grosso, forming the great water-shed of the Paraná, and the north. The highest chain of these mountains of the interior is situated to the north of Villa Rica, the capital of Brazil, and is connected by means of a lateral ridge with the coast range. The culminating point of this chain, and of the whole of Brazil, is the mountain Itambe, 5,800 feet in elevation. South of this is the Serra do Piedade, 5,836 feet; Itacolumi, 5,750 feet; the peak of Caraca, Itabipoca, and the mountains of Caraca, Itabipoca, and the mountains of Serro do Espinhaço" (Backbone ridge), not only because it is the highest ridge of the system of Brazil, but also because it forms a most important natural division. The other great undulating ridge which forms the water-shed from south to north, has been called, by Eschwege, "Serra do los Vertentes" (Watershed mountains). Its highest points, none of which, however, exceed 2,000 feet, are Serra do Canastea and Marcella. The Pyrenees, which in the province of Goyas, separate the tributaries of the Tocantins from those of the Paraná, belong to this range. To the westward, in the province of Matto Grosso, mountains and hilly formations entirely disappear; the affluents of three great rivers, the Topajos, Madeira, and Paraguay, are separated by an undulating plain, which, from the nature of its soil, from the so-called Campos Parecis, extensive naked plateaux, devoid of vegetation, which, although they are situated in the interior of the continent, nowhere attain the height of 1,000 feet. Their whole physiognomy, indeed, resembles the plains of Gobi in Mongolia.

D.—PLAINS.

A particular description of the plains of the southern part of the New World is unnecessary, since their boundaries and extent are defined by the mountain ridges. We shall, therefore, confine ourselves to a brief sketch of their general condition, in which we shall be guided chiefly by Humboldt. The llanos and pampas of South America are true steppes. In the rainy season they display a surface of beautiful green, whilst in the dry season they assume the appearance of a desert. Then the grass crumbles into dust, the soil is rent, the crocodiles and boas bury themselves in the mud, which is buried-up mud, till the first showers of spring arouse them from their torpidity. These phenomena occur over a space extending to many square miles, wherever the savannas are not intersected by rivers. On the borders of brooks and ponds which contain putrid water, the traveller meets with groups of fan palms, whilst, remote from the water, the mauritia disappears.

All these plains are very little elevated above the level of the sea. The llanos of Venezuela, at Villa do Po, Calabazo, and at the mouth of the Meta, are not more than from 250 to 320 feet above the level of the ocean. The fall of the river is here extraordinarily weak, often unobservable; and the water of the Orinoco, and of the Cassiquiare, reverses its course twice a year. The absolute want of hills and inequalities—the perfect level of all parts of the surface, is a characteristic feature of the steppes of South America, and hence the Spaniards who first discovered, called them Llanos, or level fields. The pampas of Buenos Ayres, although the surface does not vary a single foot, are 1,300 feet. But notwithstanding this uniformity of surface, the llanos present two kinds of inequality:—first, the banco, true benches, rocks in the basin of the steppes, broken layers of sandstone or limestone, which rise four or five feet above the level of the plain, often extending for a distance of several miles; and the mesas, or table-lands, which are perceptibly rise to a height of 1,000 feet above the plain, and can be discovered only by the course of a stream, or by careful levelling. In the llanos of Venezuela, the mesas of Amana, Guanipa, and Iguare, extending from south-west to north-east, separate the waters of the Orinoco from those which flow to the northern coast.

The great uniformity, extreme rarity of habitations, the fatigue consequent on travelling under a burning sun, and in an atmosphere darkened by dust, the view of the horizon, which continually appears to recede, the isolated palm trees, which have all a peculiar physiognomy, and which the traveller, mistaking one for another, despairs of reaching, as they gradually rise above the horizon; all these causes united give to the steppes an appearance of much greater extent than they have in reality.

The colonists inhabiting the southern declivities of the coast chain of Venezuela see the steppes extending towards the south, as far as the horizon ocean, so far is the eye from reaching that. It is possible to travel from the delta of the Orinoco, over the Meta, the Guaviare and the Cagnan, beyond the equator, to the foot of the Andes of Pasto, a distance of 1,100 miles, without quitting the plains. They know, from the accounts of travellers, that the pampas of Buenos Ayres, which are also tree-less and covered with grass, extend to the south of the Rio Colorado, and that the plains of the Amazon extend on both sides of the equator, between the two basins. The intermediate basin, which, throughout the year, is watered by the equatorial rains, is almost entirely an immense forest, through which the rivers form the only passage.

From the strength of the vegetation concealing the surface of the soil, its uniform level is rendered less remarkable, and hence it is usual to designate as plains, only the llanos of Caracas and those on the banks of the Plata. According to the Spanish colonists, the three basins into which the great plain of South America is divided are distinguished from one-1. The llanos of Venezuela and Caracas (Venezuela). 2. Bosques or Selvas (forests) of the Amazon, and the pampas of Buenos Ayres. The forests cover not only the greater part of the plain of the Amazon, from the Cordillera of Chiquitos to the mountains of Parime, but they crown both these mountain chains, which seldom reach the height of the Equinoctial region. They also cover the mountains on the banks of the Madeira and those of the Rio Negro, are not so clearly defined as the llanos of Venezuela, and the pampas of Buenos Ayres. Since the zone of the woods includes plains as well as mountains, it extends from lat. 18° S. to lat. 7° or 8° N., covering an extent of nearly 780,000 geographical square miles. This South American forest—for, properly speaking, it is only one—is six times the size of France, or as large as Russia in Europe. It is known to Europeans only on the banks of a few of the streams by which it is intersected; and it has its clear spaces, the extent of which is in proportion to that of the woods. The llanos of Venezuela, where they extend in a parallel direction, are six times less than the great desert of Africa. This proportion is very important in a region where the wind blows constantly from east to west, since the further the plains extend in this direction so much more heat do they radiate, and so much warmer is the climate.

[1] See the Section of Quito on an enlarged scale in the West of Geological Panorama, No. 8, of this Geography.

[2] See the Section of Trinidad on the great sheet, No. 4, of this Geography.

ON

GLACIERS AND GLACIAL PHÆNOMENA.

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I. ON THE DISTRIBUTION OF PERMANENT SNOW ON THE EARTH'S SURFACE.

In the description of the Map of Isothermal Lines, the general phenomena of climatology have been glanced at. The dependence of the average annual heat of the earth's surface on the latitude was exhibited by means of curves which point every point possessing the same mean temperature. The intervals of these lines, or the spaces corresponding to equal differences of mean temperature, are widest near the equator, and closer in higher latitudes (supposing them correctly represented on a spherical surface); they do not follow the parallels of latitude with accuracy, but for about half the surface of the globe they approximate to them. The limits of mean yearly temperature which have been satisfactorily observed vary between 84° or 85° Fahrenheit, and 0° of that scale (+ 29 to — 18 cent.) Supposing, then, for a moment, the variation of the seasons abolished, and the mean temperature constant throughout the whole year, there would be a considerable part of the earth's surface where fresh water would be unknown in the liquid form, and where even salt water could only be obtained by piercing through an immense thickness of permanent ice. The phenomenon of rain would be unknown. The natural covering of the earth would be snow, as that of the water would be ice. Now there is an approximation to such a state of things. In certain latitudes, snow and ice are as much the habitual covering of the globe as earth and water are elsewhere, although this effect does not necessarily take place at the isothermal line of 32°, or where the mean annual temperature is at the freezing point; for the perpetuity of snow at any point does not depend on the mean temperature, but on the fact that all the thawing influences of the summer period of the year balance all the freezing and accumulating influences of the winter period.

But besides the effect of latitude, the influence of height is productive of cold; and the ascent of a high mountain between the tropics leads the naturalist, within the compass of a day or two, through the whole range of climate which months of laborious journeying towards the arctic regions would be required to exhibit. Vegetation has a similar progression in the one case as in the other (see the map illustrative of the Geography of Plants): the palm and aloe yield to the chesnut and the vine—these to the oak and beech—these again to the hardier pines—the pines to the dwarf birch and rhododendron, and these to simple grasses and lichen, till at length perpetual snow bounds the outskirt of vegetation, as well in vertical as in horizontal extension. The level of perpetual snow, which in the Cordillera of Southern America reaches the height of 18,300 feet (5,650 metres), has descended in the Alps of Europe to 8,900 feet (2,700 metres); in Norway, in latitude 71°, to 2,400 feet (720 metres.) For the reasons already mentioned, especially the enormous differences of temperature in the arctic regions under the same parallel of latitude, these numbers give only a very partial insight into the state of the facts. In particular, many authors have doubted whether the surface of *perpetual congelation* (as it has been commonly but erroneously called) touches the level of the sea at all. The mean temperature at the snow line near the equator is 34°.7; in the temperate zone it is 25°.5; in the arctic regions about 21°: but we have the mean temperature of Melville Island = 0° of Fahrenheit; therefore, it might be conceived to be surrounded by a vast waste of perpetual snow (see the Map of Isothermal Lines of 20°). Such a conclusion, however plausible, appears to be unsound. The best authorities agree that even in the most rigorous polar climates of the Northern Hemisphere, the extreme dryness of the climate, and the perpetual day of summer, occasion the complete disappearance of the snow in level positions, which gives place to positive vegetation suitable for the support of arctic animals. In the antarctic regions, however, the line of perpetual snow at the sea level is reached between 67° and 71°,[1] the difference probably arising from the greater humidity of the atmosphere there. The complete disappearance of the snow fallen in winter is a complex phenomenon, and cannot be expected to follow any simple law, or to be regulated by the mere geographical position. It depends, for example, as much upon the depth of the fall of snow as upon the heat of the summer, and very much upon the prevalent winds, and upon the exposure. Hence, even on the same group of mountains, the snow level varies greatly. In the Alps it is probably 700 feet lower on the northern than the southern side, whilst in the Himalaya range, by a singular inversion (which we cannot here stop to explain), it is about 3,000 feet higher on the side of Tartary than towards Hindostan.

Thus the limit of perpetual snow over the globe is bounded approximately by a spheroidical surface flatter than the terrestrial spheroid, and cutting it in the vicinity of the poles.[2] Thus also the habitable earth is bounded in all directions by regions which appear to be designedly rendered inaccessible, just in proportion as they are incapable of supporting human life. The polar regions are guarded by the bulwarks of their inhospitable climate, where "winter barricades the realms of frost." Were a large portion of the earth's surface situated at a higher level than it is, it would be placed beyond the uses or occupation of man, whose physical powers fail as the increasing rigour of the higher atmosphere renders his maintenance impossible. And even if he were to seek emancipation from the boundaries of his mortal prison in the depths of the earth, the increasing temperature of his mines opposes a not less impassable obstacle to the enlargement of his domain in that direction.

The portion of the earth's surface under perpetual snow has never yet, we believe, been estimated. The most conspicuous masses, next to the antarctic regions, are the Cordillera, the Himalaya range, the Altai and Ural, and the Alps; but from the steepness of most elevated summits, and the absolute want of very elevated table-lands (see the article on the Mean Height of Continents in the Physical Atlas), the area they present is inconsiderable.

From the variable elevation of the snow line, the snow-clad portions of mountains are very disproportionate to their height in different latitudes. Chimborazo, in Peru, so long supposed to be the highest mountain in the world, rises only 5,000 feet above the snow line; whilst Mont Blanc, in Europe, of which the absolute height is 6,000 feet less, is covered with perpetual snow for the upper 7,000 feet of its elevation. The Himalaya, indeed, whose heights have till lately been considered almost fabulous, but which are now well ascertained, in several instances, to exceed 25,000 feet, rise 9,000 above the snow line on their southern, and more than 12,000 feet above that on their northern slope. The only parallel for this prodigious elevation above the snow line is singularly enough presented by one of the most striking and unexpected of modern geographical discoveries, Mount Erebus, an active volcano, rising 12,000 feet above the ever-frozen shore of the Antarctic Sea, within 13° of the pole, which, all unseen by man, has vomited for thousands of years its fiery flood, amidst the unbroken solitude of that frozen wilderness, until discovered by Sir James Ross in 1841. These relations of the snow line are fully illustrated in the Plate, fig. vi.

On this subject space only allows me to add, that the height of the snow line depends materially on the extent of snow-clad surface rising above it; an extensive snow-capped chain or group of mountains lowering the level of perpetual snow, whilst an isolated summit may rise above the level of the theoretical snow line without retaining the snow for the whole year. Thus the volcano of Mouna-Roa, in Owhyee (latitude 20° north), though it attains a height of 13,800 feet, does not reach the snow line. Perhaps, for the same reason, the highest mountains of Scotland do not reach the true snow line, although snow often lies for the whole year in shady places.[3]

II. GLACIERS.

It is now time to distinguish, more particularly, one of the most peculiar features which often though not invariably, accompany perpetual snow—I mean the existence of glaciers.

A glacier, in the most correct meaning of the term, is a mass of true ice, possessing hardness and transparency, which, descending below the usual snow line, prolongs its course down the cavity of one of those vast gorges which furrow the sides of most mountain ranges. Any one who is placed so as to see a glacier in connection with the range from which it has its origin, at once infers that it is in some sense or other the outlet, or rather the overflow or waste, of the vast snow fields which occupy the higher regions. It may be compared not unaptly to an icicle descending from a snow-covered roof; and its magnitude is usually exceedingly small compared to the extent of the snow fields whence it draws its origin. These seems, indeed, to be a well established connection between the one and the other, such as necessarily subsists between the area of drainage of a valley and the size of the stream which flows through it. A small or single valley has a puny rivulet; but if it divide into extensive ramifications, and its springs spread over a large mountain district, a large torrent is the result. Hence, a glacier being a peculiar prolongation of the limit of perpetual snow, under peculiar circumstances, its boundary is by no means determined by anything like the snow-plane in any country. The mere existence of it in a position where we know that waste must predominate over supply, proves that it has a motion bodily downwards, which repairs the extraordinary waste to which it is subjected, by intruding its gelid mass into the inhabited and cultivated valleys of the Alps.

III. THE INFERIOR LEVEL OF GLACIERS

depending upon partial, not general phenomena—on the quantity of ice compared to the surface which it exposes to the thawing influences, on the exposition of its valley, and other circumstances—is exceedingly irregular. Thus, though the snow line in the Alps does not commonly descend below 8,600 English feet, the Lower Glacier of the Aar descends to the level of 5,900 feet, that of Rosenlaui to 5,100 feet, the Upper Grindelwald Glacier to 4,200, the Lower Grindelwald Glacier to 3,400, whilst the source of the Arveiron at the base of the Glacier des Bois, in the Valley of Chamouni is about 50 feet higher.

This protrusion of the icy mass to a lower level than the snow line is a phenomenon depending apparently upon its consistence. If the theory which we shall, in the course of this article, endeavour to explain, be correct, the meteorological conditions which produce a highly liquefied, *sludgy* state of the accumulated snows, are the most favourable to the production of glaciers, and to their progress into the valleys, by producing a certain ductility of parts which enables them to overcome obstacles otherwise insurmountable. But be this as it may, it is certain that the meteorological conditions of the temperate regions develop the growth of glaciers more than those of either polar or tropical regions.

IV. GEOGRAPHICAL DISTRIBUTION OF GLACIERS.

ASIA.—Within the tropics, notwithstanding the considerable snowy masses of the Andes and Himalaya, true glaciers descending below the limit of perpetual snow appear to be unknown. In the South American Continent, we have Humboldt's positive assurances of this fact,[4] which he ascribes with probability (1) to the extreme steepness of most of the snow-covered peaks (which is well borne out by the figures in his *Atlas Pittoresque*); and (2) the excessive dryness of the air in these elevated regions, which prevents any accumulation of infiltrated water. To these reasons may be added a third, suggested by M. Elie de Beaumont, that the annual changes of temperature are trifling, and penetrate but a small way into the snowy masses. In the Himalaya, where the snowy masses are very extensive, from which numerous large rivers take their origin, the absence of glaciers is more extraordinary. Mr Baillie Fraser,[5] describes the source of the Ganges as occurring in a semicircular hollow of very considerable extent, formed by five principal peaks, and filled with eternal *snow*, from the gradual dissolution of which the principal part of the stream is generated. A little further north, however, on the declivity of the Himalayan range, towards Chinese Tartary, and in the mountains of Kounoun, the glacier formation is apparently first developed; and it will be recollected that it has been already stated, that upon that slope of the great Asiatic chain, the snow line is some thousand feet lower than upon the side of Hindostan. The glacier of the source of a tributary of the Indus, in Little Tibet, in latitude 35° 40′, is thus unequivocally described by Mr Vigne, in his travels through Kashmir:—

"But the glory of the valley is the magnificent glacier at the end of it. Its lower extremity is a short distance from the village of Arindo, and the natives say that it is slowly but perceptibly advancing. It occupies the entire valley, as far as the eye can reach, and a place that looks more like the extremity of the world does not exist in nature. Vast mountains, alike bare, precipitous, and rugged, appear to

[1] Private Letter of Sir James Ross.

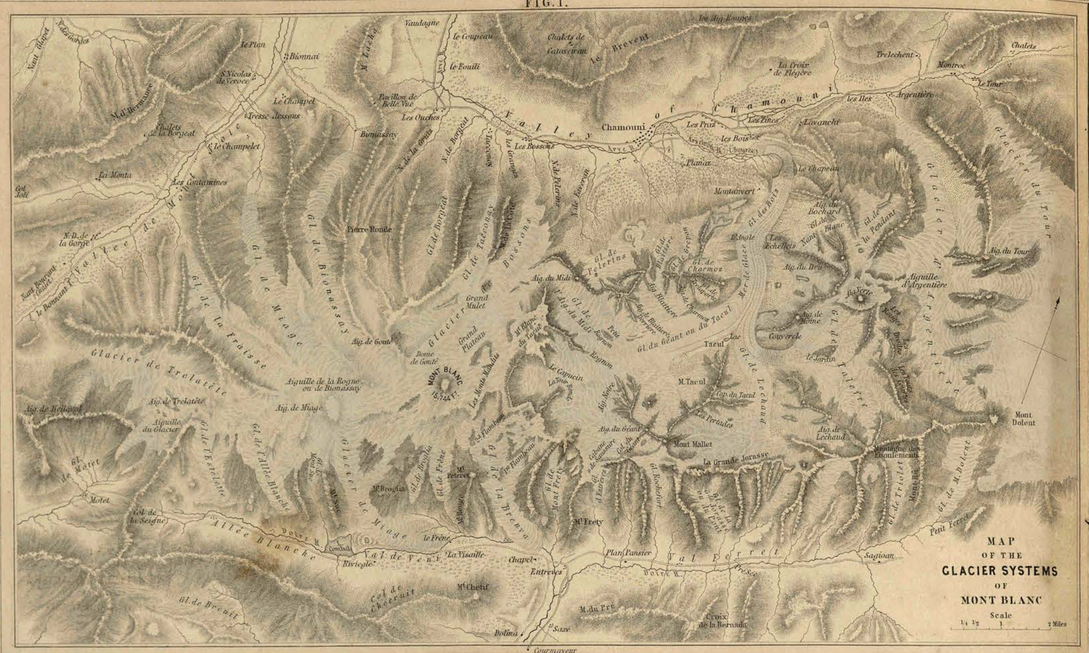
[2] Astronomers have ascribed a peculiarly luminous appearance, near the poles of the planet Mars, to the existence there of perpetual snow and ice.

[3] "Sir Henry Munro holds a forest from the crown by a very whimsical tenure—that of delivering a snow ball on any day of the year that it is demanded; and he seems to be in no danger of forfeiting his right by failure of the quit-rent; for snow lies in the form of a *glacier* in the chasms of *Benevenish*, a neighbouring mountain, throughout the year."—Forbes's *Tour in Scotland*, 4to, i. 125. Ben Wyvis is in latitude 57° 40′ north.

[4] *Asie Centrale*, iii., 264.

[5] *Ed. Phil. Journal*, i., 127.

FIG. I.


Valley of Chamouni
Chamouni
Glacier du Tour
Glacier de Trelatête
Glacier de Mianje
Aiguille du Dru
Aiguille Verte
Aiguille d'Argentière
Mont Blanc
Mont Dolent
Col de Balme
Col de Voza
Col de Bonhomme
Col de Seigne
Col de Ferret
Col du Grand St Bernard
Martigny
Sallanches
Bonneville
Cluses
Servoz
Sixt
Le Prieuré
Le Tour
Argentiere
Les Bois
Les Pratz
Les Bossons
Les Pelerins
Les Ouches
Les Tines
Les Praz
Les Tissieres
Les Tines
Le Chapeau
Le Montet
Le Tapia
Le Tremblay
Le Fouilli
Le Coupeau
Le Planet
Le Biennay
Le Chapelet
Le Chapelet de la Poyat
Le Monta
Les Gottannes
Les Granettes
Les Tissieres
Les Tines
Les Praz
Les Bossons
Les Pelerins
Les Ouches
Les Tines
Les Praz
Les Bois

6. Glacier de Miage (de Faucigny), so termed to distinguish it from the Piedmontese Glacier de Miage, with one branch of which it appears to unite on the western ridge of Mont Blanc. It is rumoured that a passage is practicable between these glaciers. Judging from the appearances on the south side, the practicability at present is more than doubtful.

7. Glacier de la Fraisse.

8. Glacier de Trélatête.

9. Anonymous Glacier, descending behind the Aiguille du Glacier, towards Mont Javet. By this glacier it is probable that the chain may be crossed to the Hameau du Glacier, on the south side.

The first four of the above glaciers belong to the Valley of Chamouni; the next six to the Val de Mont Joie.

10. Le Glacier, anonymous, an immense and splendid glacier, which descends into the Valley of Motet, and gives its name to the Aiguille (du Glacier), whose southern steep it clothes, and to the Châlets (du Glacier), at the foot of the Col de la Seigne. The stream arising from it traverses the Valley of Bonneval, and becomes a considerable tributary of the Isère. Next, in the Allée Blanche,

11. Glacier de la Seigne.

12. Glacier de l'Allée Blanche, has formerly protruded its moraine into the valley, and dammed up the river, forming a lake. This is now dry, and the barrier partly burst. The glacier has retreated.

13. Glacier de Mont Sac, or Aiguille Rouge.

14. Glacier de Miage, already described. Its moraine is perhaps the largest (due to actual glaciers) in the Alps. It fills a wide valley to the distance of four miles, and by its obstruction has formed the Lac de Combal, pushing the river into a narrow channel.

15. Glacier de Broglia.

16. Glacier de Frêne.

17. Glacier de la Brenva, near Courmayeur, one of the most accessible and most beautiful in the Alps. It descends from a portion immediately to the east of the summit of Mont Blanc. For continuity and elevation it may be compared to the Glacier de Bossons, but the result is finer; the glacier spans the valley, rising against the foot of the Mont Chetif on the side opposite to Mont Blanc. The river works its way completely beneath the ice. In one particular this glacier is peculiarly interesting, namely, for the astonishing variations of magnitude which it has undergone in the course of a few years. In the time of De Saussure (1788) he is very justly led to believe that the glacier did not reach down to the River Doire; and it is so represented in Raymond's map, and in every one, including Keller's, down to the time of publication of my Travels in 1842; which shows how little maps can be depended on for the establishment of physical facts as they existed at the date of their construction. In 1818, it had not only passed the river, but raised itself to so enormous a height as to cover and destroy the path which led, and still leads, at a height of several hundred feet (the exact height I regret not to be able to state) above the bed of the Doire, and that with so irresistible a force, as to shatter even the limestone rock of the hill, and to ruin a chapel which was built on that rock.[1]

18. Glacier de Mont Frety.

19. Glacier d'Entrèves.

These two small and steep glaciers are divided by the Mont Frety, a narrow ridge which leads to the Col du Géant. The Glacier d'Entrèves, communicates with the Col du Géant, and by it with the Glacier du Géant on the north side of the chain.

Next, in Piedmontese Val Ferret:—

20. Glacier de Rochefort, descends from behind Mont Mallet.

21. Glacier de la Grande Jorasse from behind the Grande Jorasse, called also Glacier du Pont.

22. Glacier de Triolet descends from a peak near the head of the Glacier de Lechaud, called in *patois* Durotins, or Montagne des Eboulements. This glacier occasioned one of those fearful accidents of which several are recorded in the Alps. The motion of the ice becoming accelerated, a large part of the glacier detached itself from its bed, invaded the valley beneath, completely overwhelming the châlets of Pré de Bar, which were exactly in front of it, destroying the inmates and the cattle. This happened in the night of the 15–16th August, 1728.

23. An anonymous glacier, beyond the Glacier of Triolet, descends probably from the Mont Dolent. The following belong to the Swiss Val Ferret:—[2]

24. Glacier de Mont Dolent.

25. Glacier de la Neva—opposite to the Glacier du Tour, in the Valley of Chamouni A passage across the chain has been effected by means of these glaciers.

26. Glacier du Mont Dervé.

27. Glacier de Plancreuse.

28. Glacier de l'Arpetta, d'Orsières.[3]

29. Glacier d'Orny. Descends from the Aiguille of the same name.

30. Glacier de l'Arpetta de Champsé.[4]

31. Glacier de Drance.

The following are on the north face between Martigny and Chamouni:—

32. Glacier de Trient. Descends from the Aiguille of that name, and descends pretty deep into the confined Valley of Trient. In its lower region it is easily traversed.

33. Glacier du Tour. Terminates near the hamlet of that name. The lower part is very steep, but the higher part comparatively even. It is separated from the Glacier of Trient by the Aiguille de Trient, and from the Glacier of Argentière, by the Aiguilles of Argentière and Chardonnet; and between these two Aiguilles there is an icy communication which appeared to me to be practicable.

34. Glacier d'Argentière. One of great extent and elevation. Like the Glacier de Miage, it is almost a *simple* one or nearly so, presenting no prominent subdivision or very important tributary. A considerable part of it is above the level of perpetual snow. From its extent and elevation it is difficult to explore, and seldom visited. It is separated from the Mer de Glace by the vast pyramid of the Aiguille Verte, and the upper part adjoins the Glacier of Talèfre, being separated only by a narrow, though most precipitous chain of Aiguilles. At the farthest extremity of the Glacier d'Argentière, is an elevated and very steep pass, which leads over to the Mont Dolent, near the Col Ferret. The relative positions of this glacier to the neighbouring parts of the chain are, it is believed, correctly shown for the first time in the adjoining map.

Thus we have enumerated no less than thirty-four considerable glaciers which bound the snowy region of the chain of Mont Blanc. Estimating at ninety-five square miles the surface of the ice and snow belonging to it, each glacier will have on an average nearly three square miles of surface, including the share of *névé* contributing to its formation.

One word remains to be said of the map here presented to the reader. It was originally intended to adopt Raymond's map of Mont Blanc implicitly, with the exception of the Basin of the Mer de Glace, surveyed and mapped by myself, which was to be incorporated into the other. But this combination, as might have been foreseen, produced an incongruous whole, and whilst trusting as far as possible to Raymond for the positions of the rivers and principal summits, it was found necessary to adopt material changes in the configuration of the chains, and especially in the positions and forms of the glaciers, for which I adopted all the assistance which my own notes and sketches, as well as published views and descriptions afforded. It was found absolutely necessary to increase the distance between Courmayeur and Chamouni, as given by Raymond, not only on the authority of my own survey, but from the few but valuable data of positions and distances furnished by De Saussure's memorable sojourn on the Col du Géant.[5] These, in fact, have been most relied on for connecting my map with Raymond's, together with the indication of the cardinal points. The result of much labour and adjustment is, after all, in some degree conjectural, and cannot be considered as entirely satisfactory. Still, I have reason to believe that the map is a much more faithful representation of the district than any yet published. Very many names have been added, chiefly on the authority of De Saussure, and from my own inquiries.

2. MAP OF PART OF THE BERNESE OBERLAND. Fig. II.

As this map is, in general, a copy of the old map of Weiss, the foundation of all later attempts to represent with increased definiteness, though without increased accuracy, this glacier region, and as the same *general* considerations apply to it as to the former groups, I shall discuss it as briefly as possible. It is confessedly exceedingly imperfect and rude; some names have been added chiefly on the authority of Gottlieb Studer.

The general direction of the chain of Alps which separates the Valley of the Rhone and the Canton of Berne is inclined nearly 10° more to the meridian than that of Mont Blanc; being North 59° East, and South 59° West; but in the part which we have selected for illustration, the line or direction of the chain appears to be lost, owing to the knot or group of remarkable mountains which are formed upon it. The actual boundary of the chain passes through the crooked line, embracing the Breithorn, Jungfrau, Finsteraarhorn, Kästlihorn, and Siedelhorn. And on either side is a lateral group of remarkable elevation and boldness, that of the Aletschhorn on the south, and the Schreckhorn and Wetterhorn jointly on the north side of the chain. These detached groups are divided from the main chain by glaciers remarkable for their majestic extent, the great Aletsch Glacier in the first case, prolonged by the Glacier of Lötsch; and the Lower Aar Glacier in the second, prolonged by the Lower Grindelwald Glacier. The two vast double ice valleys just named have been traversed, though only of late years; the great distance over which the ice extends, and the considerable elevation to which it reaches, offering a not inconsiderable risk in the varying climate of these latitudes. The brothers Meyer of Aarau were the first persons on record who traversed completely these wilds of the Oberland. The pass of Lötsch has since been crossed by Hugi, and that of the Strahleck (at the head of the Glacier of the Aar) by Hugi, Agassiz, and others.

The whole district in question contains a nearly rectangular space of snow and glacier, nineteen English miles in length, and ten broad, thus covering 190 square miles, or double the area of the snow and ice belonging to the chain of Mont Blanc.

The *Great Aletsch Glacier* is bounded on all sides by stupendous mountains, and its basin presents an area of no less than thirty-two English square miles. Its *névé* descends from three sides of the Aletsch, one of the boldest and most isolated summit in the Alps, which is believed, on the competent authority of M. Gottlieb Studer,[6] to be at least as high as the Jungfrau. This last mountain, which proudly commands the Valley of Lauterbrunnen and the Col of the Wengern Alp, and is on that side perfectly inaccessible, presents vast snowy accumulations on the side of the Aletsch Glacier, by which it is understood to have been ascended by the brothers Meyer in 1812; but some doubt rests on this achievement, which was first publicly witnessed on occasion of the ascent of Baumann and other Grindelwald peasants in 1828, and was repeated by M. Agassiz and some friends in 1841, and more recently by Mr G. Studer. The elevation is 13,716 feet; but the still higher summit of the Finsteraarhorn (14,100 feet), whose snows fall into the Glacier of Viesch on the one side, and the Lower Aar on the other, was attained first by Leuthold and Währen, two peasants of Hasli;[7] afterwards (in 1842) by a gentleman of Basle, M. Sulzer. No view of its kind in the Alps is more admirable than that from the central part of the higher Glacier of Aletsch, where, as it were, four ways meet, and the united ice-streams from three of them form the vast flat *Eisstrom*, whose inclination is only three degrees. One other peculiarity of the glacier must not be passed over. In a *bight* or bay formed by a sudden turn in its direction, and whose opening is closed by the mass of the glacier, there is a considerable lake formed every summer, called the Märill-see, at an absolute height of 7,000 feet,[8] which presents the singular spectacle of an ice cliff, whose broken fragments float in the green water just like the icebergs of the polar regions. A faithful representation is given in Agassiz' Atlas, plate xii. The Glacier of Aletsch terminates at its lower extremity in an extraordinary manner in a very deep narrow ravine, so deep and so inaccessible that it has been seen, undoubtedly, by very few persons. The principal tributaries of the Aletsch Glacier are—1st, From the head of the Lötschthal; 2d, From the base of the Jungfrau and Mönch; 3d, From the Viescherhörner; 4th, From the *Mittel Aletsch* Glacier, which descends from the Aletschhorn. Another fine glacier, the *Ober Aletsch* or *Jäger* Glacier, expires before it reaches the now low level of the principal body of ice. The length of the glacier, from the last ascent of the Jungfrau to its terminations, may be taken at fourteen English miles, and its mean breadth at one mile and a quarter.

The Glacier of the Lower Aar, first surveyed by Hugi, who took up his residence on it for some time, and since repeatedly visited, and annually inhabited for a few weeks, by M. Agassiz and his friends, presents a noble expanse; and where it is divided by the promontory called the Abschwung into the two branches of the Lauter and Finster Aar, presents a scene of grandeur, and even beauty, which few can rival. I regret that M. Wild's map, long promised in M. Agassiz' new publications, has never yet appeared, otherwise I should have introduced it into the plate which illustrates this paper. I regret this exceedingly, both on account of its importance and the beauty of the execution (which I have seen in the original drawing); and it would not be desirable to replace it by M. Hugi's, or any comparatively imperfect substitute. I refer to M. Agassiz' writings, and those of M. Hugi, for a description of all that is connected with this glacier.

We will now briefly enumerate the circumferential glaciers which belong to the snowy group we have undertaken to illustrate, extending from the Tschingel-grat, at the head of Lauterbrunnen, crossed by Hugi, to the Valley of Hasli, which, at the Grimsel, completely divides this region of perpetual snow from that of the Gallenstock and St Gothard. We shall commence with the glaciers belonging to the Jungfrau, on the side of Lauterbrunnen, as a well known point.

In the Valley of Lauterbrunnen:—

1. Eiger Glacier.
2. Kühlauinen Glacier.
3. Blanalp Alp Glacier, descends from Silberhorn (Hugi).
4. Roththal Glacier. By this all Hugi's unsuccessful attempts to ascend the Jungfrau were made.
5. Stufstein Glacier—descends from Ebene Fluh and Mittaghorn.
6. Schmadri Glacier, from Grosshorn and Breithorn.
7. Tschingel Glacier, from Tschingelhorn, affords a not difficult passage into the Kunderthal, and between the Breit, and Tschingelhorn, to Kippel in the Lötschthal.

Towards the Vallais:—

8. Lötsch Glacier. A passage is understood to be practicable to the Ober Aletsch Glacier.
9. The Ober Aletsch Glacier.
10. Great Aletsch Glacier, already described.
11. Viesch Glacier.
12. Wallibach Glacier, from Kästlihorn.
13. Munsterthal Glacier, from the Löffelhorn.
14. Ober-Aar Glacier.
15. Unter-Aar Glacier.
16. Bächli Glacier.
17. Steinlauinen Glacier.
18. Alpli Glacier.
19. Gruben Glacier.
20. Gauli Glacier, descends into the romantic Urbachthal. It may be used to pass over to the Lower Aar Glacier.
21. Hängend Glacier.
22. Grunbergli Glacier.
23. Rosenlaui Glacier.
24. Upper Grindelwald Glacier.
25. Lower Grindelwald Glacier leads to the difficult pass of the Strahleck, on the one hand, and by the back of the Eiger to the Aletsch Glacier, on the other.

VI. CLASSIFICATION OF GLACIERS.

Glaciers may be classified according to their external forms, which are determined mainly by the figure of the surfaces on which they rest.

1. *Canal-shaped*, of which an example is found in the Glacier de Miage (fig. vii.), which has scarcely any branches, and in the Mer de Glace of Chamouni (fig. iii.), which has two principal tributaries. The Glaciers of Miage, and Aletsch, of the Upper and Lower Aar, the Lower Glacier of Grindelwald, the Glacier of Zermatt, and especially the very striking Glacier of Viesch in the Vallais (see Agassiz' Atlas, plate x.), are examples of this description of glacier.

2. *The oval-shaped Glacier.* Of this, the Glacier of the Rhone may be taken as a type, or that of Allalein in the Valley of Saas (fig. viii.), which produces a lake in the same way as that of Combal in the Allée Blanche. Of this kind are the Glaciers of La Brenva, and the Upper Glacier of Grindelwald.

3. *The basin-shaped Glacier* is contained in a cavity of the mountains of an oval form, so that the breadth of the outlet is not a large fraction of the diameter of the glacier itself. Fig. ix. shows a ground-plan of the Glacier of Talèfre (a tributary of the Mer de Glace), the outlet of which has but one-seventh of its greater diameter.

4. *Glaciers of the second order.* These are exceedingly numerous, and denote the small glaciers which are found niched in the rocks of the higher Alps, without any connection with the great glaciers which descend below the level of the snow line. The smallness of these glaciers (which probably appear and disappear, in some cases, from time to time) is owing to the smallness of the area of snow whence they draw their nutriment. They therefore die away at a short distance from their origin. The name of Glaciers of the second order was given by De Saussure, and was intended to include those which occupy *cols* or mountain passes, such as the Col du Géant, the Col du St Theodule, the Col of the Grüs. Other glaciers of this kind are almost numberless in the Alps. An idea of their appearance may be had from plate ix. of my work on the Alps of Savoy, and fig. 4 in this map, which is a plan of one near the Simplon.

VII. SLOPE AND CONTOUR OF GLACIERS.

The slope of glaciers is very variable, commonly greater in the highest and lowest parts of their course, and least in the middle. Fig. v. shows the mean slope of different portions of the Mer de Glace. The *surface* of the glacier below the snow line is *convex* (see the sections in fig. iii.); above the snow line (in the *névé*), concave. This was supposed to be due to the reflected heat, from the ground melting the lateral parts, but it appears to be owing to a far more general cause.

VIII. RATE AND CAUSE OF MOTION OF GLACIERS.

This part of the subject being one properly of pure physics, not immediately connected with physical geography, cannot receive anything like a full treatment within the limits prescribed to us. It may, however, be stated that the rate of motion of a glacier from day to day and month to month was first correctly ascertained by my observations on the Mer de Glace in 1842. Notwithstanding the interest which the subject had excited, and the ample means employed by different naturalists for investigating it, the value of a correct determination of this fundamental fact was unperceived, and no adequate means taken for fixing it. The annual motion generally admitted a few years ago, on the respectable authority of Hugi, was fourteen feet a-year at Chamouni, and twenty-six feet at Grindelwald; and this result was said to have been obtained by sticking fir trees into the crevices, and watching their motion. Had the experiment been correctly performed, the fourteen feet just mentioned would have been found to be moved over from five to ten days (according to the position), instead of in 365! It is curious to find a competent physical writer like Raymond accepting these results, and then exclaiming: "Cette vitesse (quatorze pieds) est enorme!" Even in the most recent times, the Swiss naturalists, Hugi and Agassiz, differed in the proportion of three to one in the annual motion assigned to one and the same glacier—that of the Aar—and the latest experiments prove the error to have lain with the most recent observer. The general results of my observations, now sufficiently confirmed from other observations, are these:—

(1.) That the motion of the Mer de Glace during summer and autumn is as great as four feet in twenty-four hours in some places, and only eight or nine inches in others.

(2.) This motion is rigorously *continuous*, and not by fits and starts.

(3.) The velocity (*cæteris paribus*) increases with the slope.

(4.) The velocity is in direct proportion to the heat and moisture of the weather jointly.

(5.) That the velocity, though diminished (according to this rule) in winter, is never null, or nearly so.

(6.) The centre of the glacier moves faster *in every case* than the sides (contrary to the formerly received opinion). It is found that the top moves faster than the bottom.

(7.) The variation of velocity from point to point is greatest near the side. In the centre it is sensibly uniform.

(8.) The change of velocity at different points of the breadth of the glacier takes place in a perfectly graduated manner, by the yielding of the entire mass, not *par saltum*, nor by the jostling of detached fragments, nor by the formation of open rents.

These eight *facts of motion* demonstrated in my "Travels in the Alps of Savoy" appear to be only consistent with the theory which I have founded upon them, namely, that the glacier slides over its bed in the same manner as a cohering semi-fluid would do; the semi-fluidity being necessary to commence the motion, where the contracting form of the valley or irregularity of the bounding edges could not possibly permit the escape of the mass of the glacier considered as a solid body. The Glacier of Talèfre, for instance (fig. ix.), presents a single narrow opening, by which the annual overcharge of the

[1] See the attestation of these singular facts in my Travels, pp. 265, 266, and in Captain Hall's Patchwork, i., 103.
[2] For the correct enumeration of these, I am indebted to a kind communication of M. de Charpentier.
[3] Or Glacier de Portalet.
[4] Probably that marked Saleina by Keller.
[5] Voyages, § 2035.
[6] Topographische Mittheilungen aus dem Alpengebirge, 1842.
[7] Hugi Alpenreise, 1830, p. 208.

[8] Aletsch lakes, 7,181 French feet.—*Hugi.* By an extraordinary mistake in Keller's Map, the height is marked 4,320 French feet.

form a channel for it, and, in the extreme distance, their sides are coloured with the red and white tints of iron and gypsum. The width of the lofty wall of ice, in which it terminates towards Arindo, is about a quarter of a mile; its height is nearly 100 feet. The only way in which I can account for the quantity of soil and rock upon its upper surface (on which I gathered several plants), is, that it must have been collected partly by the effect of winds, and partly by the avalanches of ages past, which fell upon it, and deposited a detritus, when as yet, from the narrowness of its bed, it was more within range of their descending forces. I have never seen any spectacle of the same nature so truly grand as the debouchure of the waters from beneath this glacier. The ice is clear and green as an emerald; the arch-way lofty, gloomy, and Avernus-like. The stream that emerges from beneath it is no incipient brook, but a large and ready-formed river, whose colour is that of the soil which it has collected in its course, whose violence and velocity betoken a very long descent, and whose force is best explained by saying that it rolls along with it enormous masses of ice, that are whirled against the rocks in its bed with a concussion producing a sound resembling that of a distant cannon, and, if not permanently intercepted by them, may be seen floating on the Indus, even below the Valley of Iskardo."[5] In other parts of the same volume the mention of glaciers is frequent, and they are marked in his map as occurring in the district of Kashmir, in as low a latitude as 34° 13'.

In the Altai, glaciers are rare; one, however, the Katunj Glacier, has lately been distinctly described.[6] It descends from the Mountain Bjelucha, the Russian Altai (11,000 feet), and is a mile and a-half long. In the Caucasus the existence of glaciers may be considered as still uncertain. It is doubtful whether the Ural reaches the limit of perpetual snow.

EUROPE.—In Europe glaciers attain a most perfect development in the great chain of Alps, the Pyrenees being nearly destitute of true glaciers, although rising far above the limits of perpetual snow, but throughout very limited spaces.

The most southern part of the Alps with which I am acquainted, where true glaciers occur, is the Chain of Mont Pelvoux, in Dauphiné, under a latitude somewhat less than 45°. There are no glaciers surrounding Monte Viso. The Po takes its rise in a frozen lake amidst beds of snow. The principal glacier groups of the Alps are:—

1. Group of Mont Pelvoux. 2. Mont Iseran, with vast branches extending eastwards towards Cogne, northwards to the Ruitor, westwards to the Aiguille de la Vanoise. 3. Mont Blanc. 4. Mont Velan. 5. Monte Rosa. 6. The Bernese Alps. 7. The St Gothard. 8. The Bernardin. 9. The Bernina. 10. The Ortler Spitz. 11. The Adamello. 11. The Grediger Spitz, and the Grom Glockner. Eastwards of this, unless in the small group of Hallstadt, glaciers do not occur.

We shall return to the glaciers of Switzerland, and give a more detailed account of some of them. In the meantime, to continue the picture of the glacier formations in different geographical regions, we shall quote from Captain Basil Hall's faithful and lively sketch of the Glacier of Mauge, near Mont Blanc:—

"The most remarkable in the Glacier of Mauge, which not unfrequently comes all down the side of the mountain, but actually traverses the valley at right angles, dams up the stream flowing along it, and by a long series of deposits of broken rocks, the detritus of the higher ridges of the Alps, forms a huge rampart across the valley, several hundred feet high. Above this mighty natural barrier is collected the Lake of Combal, the waste waters of which have no small difficulty in finding their way past this formidable impediment. They are thrown off by a narrow channel lying between the mountains on the south side of the Allée Blanche, and the end of the embankment of rocks deposited by the glacier. It will readily be understood, that when a glacier, such as that of Mauge, though originating in the cold regions at the top, forces its way down to the warm climate of the valleys, all that part of it which consists of ice and snow, when it reaches so far, must, in process of time, be melted. But in so doing, as the huge *moraines*, or embankments of broken rocks lying on the top of the glacier, cannot be got rid of in this way, they fall down in confused heaps, as soon as the ice which supports them disappears. Moreover, it will be apparent, that as the glacier brings down a fresh supply of similar materials every season, and as a considerable portion of these fragments are disengaged every summer by the ice melting, such an accumulation must in time take place as to astonish the imagination of one not accustomed to geologist giddy. I am acquainted with only one other scene in the world which can pretend to rival, in natural magnificence, the Glacier de Mauge; I mean Niagara, which is, no doubt, even more simple in its grandeur; and being far more beautiful upon the whole, is more pleasing as an object of contemplation. The Glacier of Mauge has no pretension to beauty; it is a sort of monster whose magnificence is due *chiefly* to its enormous size, and the savage variety of its structure, coupled with its utter incongruity with the surrounding scenery."[7]

We must here observe, that though the existence of glaciers protruding below the snow line into the warm valleys seems to render it impossible to fix with any accuracy the limit of "perpetual snow," this is not really the case, for the snow line is as well marked on a glacier as on the mountains next to some authors, better. Beneath the snow line *the winter snow melts as regularly and as completely* (with insignificant exceptions) *upon the surface of the ice as of the soil*. The glacier, therefore, does not grow by its upper surface. But in the higher regions (above 8,500 or 9,000 feet in the Alps) the winter snows accumulate—more falls than melts—the glacier is in a state of perpetual accumulation, and has, consequently, a continually fresh snowy surface composed of layers. This part of the glacier is called the *névé* in French, and *firn* in German Switzerland.

As we approach the poles, the glaciers assume more and more the character of *névé*. In Scotland, though the mountains do not attain the proper snow line, masses of snow often remain unmelted in sheltered hollows; and Colonel Colby of the Ordnance Survey has informed me that he once, for curiosity, caused workmen to dig into one of these old snow beds in such a cavity, on the mountain of Lochnagar, in Aberdeenshire, and he found the lower part converted into ice. Were this phenomenon not merely local, arising from an excessive accumulation of snow over one spot, it would be a true *névé*.[8]

NORWAY—ICELAND.—In Norway are numerous glaciers, described by De Buch, Wahlenberg, and others. They occur abundantly in the mountains a little to the north of Bergen, in latitude 61° to 62°, forming the Snechnam and Juste Fond, and in the Dovrefield on Dovrefield. The mountains of Sulitelma, in latitude 67°, they descend to the level of the sea, constituting true polar glaciers. The interior of Iceland is covered with glaciers, two of the finest of which are Swinafelle-Jökull and Holnar-Jökull. The Island of Jan Mayen, in latitude 71°, contains numerous glaciers, three called icebergs, thus described by Scoresby: "They occupy recesses in the cliff where it is 1284 feet high, and nearly perpendicular, and extend from the base of Beerenberg (a mountain 6,870 feet high, seated on a base of 1,500 feet) down to the water's edge. These polar glaciers differed in appearance from anything of the kind I had before seen. They were very rough on the surface, and of a greenish-grey colour. They presented the appearance of immense cataracts suddenly arrested in their progress, and congealed on the spot by the power of an intense frost. Like cataracts, the different crevices and projections about was variegated with snow-white patches resembling foam, which were contrasted with the jet black points of the most prominent rocks peeping through their surfaces. As in cataracts, also, they seemed to follow in some measure, the figure of the rocks over which they lay, and were marked with curvilinear strie [probably *moraines*] from top to bottom."[9]

SPITZBERGEN.—The glaciers of Spitzbergen, which are highly interesting, from their extreme northern position, touching probably the line in which perpetual snow reaches the sea level, have been described by several authors, and most recently by M. Martins,[10] who has compared them with the glaciers of the Alps. The very best idea of them may, however, be formed from the excellent old engravings in Phipps' Voyage,[11] and the descriptions of Scoresby,[12] leave little to desire; want of space alone prevents us from quoting these. The largest iceberg or glacier he saw presents a frontage of eleven miles to the sea, with a cliff 400 feet high, and it extends backwards towards the mountain tops, to a height about four times as great. The truncation of these icy masses, by the action of the sea, produces the ice islands or floating icebergs, so frequent in the arctic seas, and especially in Baffin Bay. Occasionally these glaciers project their snout into the sea to a great distance, without being broken off, and possess much flexibility: thus Sir James Ross informs me that they rise and fall with the tide, to a certain extent, so that the apparent tidal variation is diminished to one half, at the extremity of such protruding glaciers.

SOUTH AMERICA.—In the Southern Hemisphere, true glaciers appear to commence on the west coast of Patagonia, and reach to the sea, in latitude 46° 40', and are numerous in Tierra del Fuego, of which an excellent account has been given by Captain King and Mr Darwin.[13] The south polar continent is almost everywhere guarded by mural precipices of ice of great extent.[14]

Such being a brief sketch of the distribution of glaciers over the globe, we shall proceed to illustrate this subject further by special reference to the topography of glaciers in the Alps, being the region where not only they are most accessible, but where, likewise, they are best developed.

V. GLACIERS OF THE ALPS.

The extent of these is estimated by Ebel[15] at 130 square leagues, equal to about 1,400 English square miles, and their number at 400. They form the source and feeders of many important rivers, especially those which take their rise on the north side of the chain, such as the Rhine and Rhone, each of which flow from glaciers bearing their name. In earlier times the extent of perpetual snow in Switzerland appears to have been much exaggerated, and a notion which, with our present knowledge of geography, seems highly absurd, prevailed—that all the glaciers of Switzerland had their origin in a common expanse of snow and ice, called a Mer de Glace, by which they were reduced, as it were, to one. Places inaccessible, and viewed from only one side, valleys and chains never ascended or crossed, became invested by the imagination with unreal magnitude; and if we consider the enormous circuits required to visit in succession the glaciers now existing from any mountain range in Switzerland, we cannot wonder that common notions of space and distance, unaided by trigonometry, should have been confounded, and a snowy connection presumed between points the most remote, which had only been visited, so to speak, circumferentially. The task of ascending mountain summits is of recent growth, and perhaps its chief benefit to the science of physical geography has been, by enabling the eye, tutored to accurate and comprehensive observation, to seize the totality of complex relations of mountain chains, of geological formations, and of glaciers.

It appears, that so late as 1776 the distinguished Swiss botanist, Haller, found it necessary in his preface to "Wagner's Views in Switzerland," now before me, to refute the idea, that the whole Alps formed a united snowy mass or *Mer de Glace*;[16] and quotes, in proof of the discontinuity, passages like the Grimsel and the Gemmi, which in summer are altogether clear of snow.

Nevertheless, there is some truth in the view, that in local groups or individual mountain masses, there is a central accumulation of snows which forms the *pabulum* or nutriment of the descending glaciers. These two parts of the common system have been named by some authors "Glaciers Reservoirs," and "Glaciers d'Ecoulement."

These groups or glacier masses have been enumerated, at least the principal of them. The two most considerable in the Alps are those of Monte Rosa and its dependencies, and of the Finsteraarhorn and its dependencies. The greatest glacier in Switzerland is probably that of Aletsch, which belongs to the latter of these systems, originating at the northern slope of the Jungfrau, and extending nearly to Brieg in the Valtais, a distance (as nearly as we can judge) of fourteen English miles, with a breadth of one and three-fourth miles in some places, and uniting the icy contributions of many vast tributaries.

It will conduce to a fuller understanding of the whole circumstances and phenomena of Alpine glaciers, and contribute to the knowledge of their geography, with which this work is more especially conversant, if we describe topographically two or three of these groups; and we select

1. The glacier group of Mont Blanc. Fig. i.
2. The glacier group of the Finsteraarhorn. Fig. ii.

1. THE GROUP OF MONT BLANC.

This is a somewhat oval group, with its longer axis extending in a direction North 49° East, and South 49° West, thirty miles from the Col de Bonhomme to the Mont Catogne, near Martigny (not included in the map); and its transverse axis about nine miles from Chamouni to Courmayeur. It is bounded by five rivers—on the north side by the Arve; on the west by the Bonnant, descending from the Col de Bonhomme; on the south by the two branches of the Doire, descending the Allée Blanche and Piedmontese Val Ferret; and on the east by the tributary of the Drance, which descends the Swiss Val Ferret. The culminating point of the chain is Mont Blanc, the highest European mountain, being 15,744 English feet above the level of the sea, according to the latest authority of the French engineers. Its measure may be considered as varying probably to an extent of twenty feet, by the varying thickness of condensed snow consolidated into ice,[17] which forms its summit. The top is of a flattened saddle-shaped form, and has been called the *Dos d'Ane*. That considerable masses of ice may exist on mountain tops, and form their summits, is shown by the Similaun, in the Oetzler Spitz, in the Tyrol, which, I have seen as a mountain with a crystalline, evidently translucent, summit. The south side of Mont Blanc is very steep, and when viewed from the Allée Blanche, appears absolutely precipitous; this is very far, however, from being the case. It will be seen by the map, that from the summit of Mont Blanc to the River Doire, is a distance of about 5,500 metres, and its elevation above the river is about 3,200 metres; consequently the angle of mean inclination will be 71°. From the side of Chamouni it is much less, the distance being more than double, and the relative height little greater. It is from that side alone that the mountain has been, or perhaps can be, ascended. The route now commonly adopted is by following the solid ground as high as possible on the east side of the Glacier du Bossons. The glacier is then crossed, and the bold rocks called the *Grands Mulets* gained, where the traveller must pass the night is passed, at a height of 10,000 feet above the sea. The traveller then enters a kind of valley or indenture, in the northern slope of the mountain, filled, of course, with snow and ice, forming the feeder or *névé* of the Glacier of Bossons, and with the prominent ridge which forms a swelling promontory, called *Dôme du Gouté*, on his right. This hollow is called the Grand Plateau; and part of the traverse is dangerous, on account of the *avalanches* which fall from the high grounds on the right. After a fresh ascent, the *Petit Plateau* is attained; the traveller then turns abruptly to the left, and commences an ascent over an icy acclivity of about 50°, in which steps must be cut, till the last rocks are reached, and soon after the summit is gained, without further difficulty than what arises from fatigue and the exhaustion which the rarified air produces in many constitutions.

The snowy scalp of Mont Blanc is the point of real union of several of the glaciers of the chain. The Glacier du Bossons, as was remarked by De Saussure, is the only one that descends from the top to the bottom of the mountain, a height of 12,300 feet. It ascends higher and descends lower than almost any other glacier in Switzerland. Its course is also excessively steep. Its mean motion I have ascertained to be very rapid. It is fed by the vast contributions of the Grand Plateau, which furnish a supply of icy material proportioned to the vast expenditure below. The largest glacier of the chain, the *Mer de Glace* (formerly called Glacier de Bozon, and it is a preferable name), does not take its origin from the summit of Mont Blanc, being divided by a rugged and impassable chain of the Monts Maudits. But the Glacier de Bionassay, which lies north-west from the summit, is probably in connection with it, occupying a chasm which extends by the Aiguille and Dôme de Gouté (see the map), as well as the Glacier of Taconnay, to the Aiguille and of La Brenva to the south-east. These four glaciers (with some embranchements, such as the Glacier of Taconnay from that of Bossons) can alone be considered as belonging to the summit of Mont Blanc. The other numerous glaciers of the chain take their rise from local accumulations of snow in the complicated systems of valleys which intersect it. The more complex and more extensive, the larger the glacier produced.

By far the largest and most complex glacier of the chain is the Mer de Glace or Glacier de Bayer, already spoken of. The lowest or terminal part, called the Glacier des Bois, gives rise to the River Arveiron, about two miles above the village of Chamouni. The Glacier des Bois is precipitous for a considerable distance, until below the chalet of Montanvert, it becomes comparatively level, having a mean slope of only 4½°, which extends for several miles upwards towards the centre of the chain, the glacier having a mean breadth of about 2,500 feet, or about half a mile, as it divides into two branches. the Glacier de Lechaud taking its origin at the foot of the Grand Jorasse, quite in the axis of the chain, and which is swelled by the contribution of the overflow of the fine Glacier of Talèfre; and the Glacier du Géant, descending from the col of the same name, 11,140 English feet in height, celebrated as the residence of De Saussure for seventeen days, having numerous tributaries, particularly one which descends from the Aiguille Blanc du Tacul, and the Aiguille du Midi. This last belongs to a peculiarly rugged chain of mountains which divide the Glacier du Géant from the valley of Chamouni, and which are called the Chain of Aiguilles (or Needles) of Chamouni. They are all inaccessible (the so-called ascents of the Aiguille du Midi not having included its highest peak), and furnish some small glaciers on the S.E. and S.W. declivities. The great extent and still greater variety of surface of this glacier, make it a condensed type of all glaciers, and admirably suited for study. Its parts may be understood from the small reduction in the plate from the large map constructed from actual survey, which accompanies my "Travels in the Alps of Savoy," to which I must refer for further details than could be suitably entered into here. The area of the basin of the mountains within which the *Mer de Glace* is situated may be rudely estimated at thirty square miles; but of this a large portion is rock, which does not contribute any share of its snowy covering to the increase of the glacier. Further: according to a rough and imperfect estimate, the whole *contiguous* surface of ice and snow connected with this glacier, is 17.83 square miles; of this, there belongs to the *névé*, or that part where the glacier *grows* from year to year, 12.30 square miles, thus distributed:—

	Square Miles.
Glacier du Talèfre, *névé*,	2.77
Névé of Glacier de Lechaud,	3.17
Névé of Glacier du Géant,	6.56
	12.30

The following portion includes the glacier proper, where the waste exceeds the supply, or the glacier *loses* matter:—

Part of the Glacier de Lechaud,	0.58
Part of the Glacier du Géant,	1.00
The United Glacier,	3.55
	5.13
Total,	17.43

We have here left out of account the area of numerous *small glaciers* (glaciers of the second order of De Saussure), which take their origin in the cavities of the higher rocks, but which, from deficient supply, never reach the main glacier below, and therefore cannot be considered as tributaries. They may be said to expire in the cradle. Such are the glaciers of the Nant Blanc, of Dru, of Charmoz, of Trelaporte, of the Périades, and many others—all in this one basin.

I estimated roughly, in the month of September, the discharge from the source of the Arveiron, at the foot of the glacier, at 300 cubic feet per second. This is considerably under its maximum discharge in July. In winter, the stream is very far indeed from being dry; perhaps, however, we should not be very far wrong in considering the quantity now mentioned as an approximation to the *excess of snow melted over the snow replaced*, which evidently corresponds to the total fusion of the glacier and *névé* in the height of summer; since in winter the flow depends solely upon the water issuing from the depths of the earth under the glacier, the drainage of the glacier, and the quantity which the native heat of the earth is capable of melting from the inferior surface of the glacier.

The map, fig. iii., shows the outline of the greater part of the glacier proper, taken from my work already mentioned. Fig. iv. represents separately the Glacier of Talèfre, with the rocky islet called *La Jardin* in the midst of it, the area of which is about 0.06 of a square mile.

We can do little more than enumerate the glaciers which present themselves in succession, in making the circuit of Mont Blanc, and serve as the outlets of the vast snowy accumulations of the chain, whose area (the area above the snow line and the glaciers together), may amount to between 90 and 100 square miles.

1. Glacier des Bois, already described.
Omitting the small glaciers belonging to the Aiguilles, four in number.
2. Glacier de Bossons, proceeding directly from Mont Blanc.
3. Glacier de Taconnay, a branch of the preceding, divided from it by the Montagne de la Côte, by which the earlier expeditions to Mont Blanc were made. This glacier appears formerly to have been much more extended, judging from its moraine, which appears to have once crossed the River Arve, and even to have extended much lower.
4. Glacier de la Gria or du Bourget, an elegant glacier descending from the Aiguille de Gouté, terminating, however, at a great height. It is very steeply inclined, but not fragmentary. It is long and narrow, and its surface *concave*.
5. Glacier of Bionassay, a fine glacier, descending from behind the ridge of the Aiguille and Dôme du Gouté. It was in this direction that De Saussure first hoped to attain the summit of Mont Blanc, and he ascended a considerable way. (Voyages, vol. ii.) There is strong reason to think that this glacier once extended itself into the Val de Mont Joie, below Contamines (see the map), since blocks of the same nature, with its moraines, may be traced down to St Gervais and Sallenches.

[1] Vigne's Travels in Kashmir, ii., 283, 266.
[2] Pottinger, by Captain Basil Hall, i., 94, &c.
[3] See Behr's interesting account of these mountains—Jameson's Ed. Phil. Journal, 1827, vol. iii., p. 253. He is the only author, so far as I know, who has attempted to estimate the diurnal fusion of a glacier. He supposes that above 5,000,000 or cubic fathoms of snow are melted into the river of Justedal during half a summer's day.—Ib., p. 264.
[4] Scoresby's Arctic Regions, i., 153.
[5] Bibliotheque Universelle de Geneve. Nouv. Serie. Tom. xxviii., published 1826.
[6] Published 1774. [7] Arctic Regions, vol. i., p. 161, &c.
[8] See note 2, last page.
[9] Leonhard's Taschenbuch, 1825.
[10] Darwin's Voyage of "Adventure and Beagle," p. 229. [11] Sir J. Ross.
[12] Guide du Voyageur en Suisse, ed. Gleizer. His remarks include only those from Mont Blanc eastwards.
[13] De Saussure, Voyages, § 2,013, thinks that the thickness of the snowy covering of Mont Blanc may amount to 200 feet.
[14] Nevertheless, there is some truth in the view, that in local groups or individual mountain masses, there is a central accumulation of snows which forms the *pabulum* or nutriment of the descending glaciers. These two parts of the common system have been named by some authors "Glaciers Reservoirs," and "Glaciers d'Ecoulement."
[15] These groups or glacier masses have been enumerated, at least the principal of them. The two most considerable in the Alps are those of Monte Rosa and its dependencies, and of the Finsteraarhorn and its dependencies. The greatest glacier in Switzerland is probably that of Aletsch, which belongs to the latter of these systems, originating at the northern slope of the Jungfrau, and extending nearly to Brieg in the Valtais, a distance (as nearly as we can judge) of fourteen English miles, with a breadth of one and three-fourth miles in some places, and uniting the icy contributions of many vast tributaries.
[16] It will conduce to a fuller understanding of the whole circumstances and phenomena of Alpine glaciers, and contribute to the knowledge of their geography, with which this work is more especially conversant, if we describe topographically two or three of these groups; and we select
[17] 1. The glacier group of Mont Blanc. Fig. i.
2. The glacier group of the Finsteraarhorn. Fig. ii.

vast basin is delivered as from a waste-pipe. Motion would evidently be impossible in such a case, except by an approximation to fluidity.

The semi-fluid (or semi-solid) hypothesis satisfies all the above conditions of observations; for

(1.) On the small inclinations of many glaciers, and with the enormous friction to which the motion of the mass is exposed, if its parts did not yield over one another, motion could not be commenced at all.

(2.) Fluid motion, by its very mode of generation, and by the minuteness of the sphere of cohesive action, is continuous.

(3.) The velocity increases as the slope.

(4.) Any cause increasing the liquidity of a semi-solid, or the effective hydrostatic pressure, will increase the rate of its flow. Such a cause is the infiltration of all the pores of the ice of a glacier by water during sunshine or mild rain.

(5.) By the laws of penetration of heat and cold into great masses, it is certain that the depths of the glacier cannot be entirely frozen even in winter.

(6.) Owing to friction, all fluids moving in channels move fastest at the centre and at the surface.

(7.) The variation of velocity in viscous fluids (such as rivers) is always greatest near the sides and bottom, and least at the centre and surface.

(8.) Owing to the smallness of the sphere of action and the mobility of the parts, no positive discontinuity of any extent can be produced in viscous bodies—they change the mutual position of their molecules in a manner sensibly *continuous*.

Other and important arguments for this theory may be drawn from the remarkable ribboned or veined structure of the ice, to which I drew especial attention for the first time in 1841, and of which an explanation was given conformably to the VISCOUS OR PLASTIC THEORY of glacier motion in 1842. But our limits positively forbid our entering on this more extended and difficult inquiry.[1]

IX. ON THE FORMER EXTENT OF GLACIERS, AND VARIATIONS OF THEIR SIZE.

1. *In Historic Times.*—Glaciers vary in size, surface, depth, and protrusion into the valleys, from one year to another, and notably during periods of ten or twenty years.[2] Some glaciers increase at the very same time that others not very distant from them diminish. These variations are difficult to explain satisfactorily. If we go back some centuries, these variations are more striking and more general. There is full reason to believe that in the fifteenth and sixteenth centuries many passes of the Alps, now exceedingly difficult and dangerous, were comparatively easy and frequented. This is established, not only by oral tradition (which is sufficiently plain), but by documentary evidence, to which we cannot here refer more minutely. Passes of this description were, for example—(1.) That by the Great Aletsch and Grindelwald Glaciers from Brieg to Grindelwald; (2.) from Saas to Anzasca by Monte Moro; (3.) from Zermat to Evolena by the Col d'Erin; (4.) from Bagnes to Aoste by Chermontane; (5.) from Chamouni to Courmayeur by the Col du Géant. On this subject I must refer to M. Venetz' excellent paper in the first volume of the Transactions of the Swiss Naturalists, and to the abstract of it in Agassiz' *Etudes sur les Glaciers*, chap. xvi.

2. *In Remote or Geological Epochs.*—The immediate neighbourhood of most of the glaciers of the Alps afford unequivocal traces of their having been much more extended at periods anterior to history than even in the present day, although we have seen that for some centuries they have been on the increase. Vast moraines, or heaps of transported blocks and gravel at considerable distances (a mile or more) in advance of the present bounds of the ice, have been admitted on all hands, at least since the time of De Saussure, to attest this fact. Those most frequently quoted are the old moraine of Lavanchi near Chamouni, belonging to the Glacier des Bois; the moraine of the Glacier of Rosboden, on the Simplon; and that of the Glacier of the Rhone. Admitting these (and almost every Alpine valley affords similar evidence) as a sufficient proof, up to this point, of the former greater extension of glaciers, we find it impossible to draw a line between them and other moraines, in or near the mouth of valleys whose heads are still occupied by glaciers; and this evidence is strengthened, if we observe the same character of the rocky surfaces which the friction of glaciers undoubtedly produces, namely, perfectly smooth rounded dome-like forms[3] (called *roches moutonnées* by De Saussure), grooves, and striæ in the direction in which the ice must have moved; and in some cases a fine, even-polished surface, such as is produced by continued attrition, but never by crystallization. Such are the phenomena seen near St Gervais, in Savoy, where (as already mentioned) the travelled granite blocks and gravel of Mont Blanc may be continuously traced from the neighbourhood of Sallenches (and probably much farther) up to the existing moraines of the Glacier of Bonnassay, and others in the same direction. Such, too, is the great moraine near Kanderstег, which must have been formed by the glaciers of the valleys of Gasteren and Oeschinen—that in the Swiss Val Ferret, formed by the glaciers descending from the Aiguille d'Orney. Such, too, are the polished rocks at Saas and at the Handeck (in Hasli), due to the anciently extended glaciers of the Montagne de Fée and of the Upper and Lower Aar. But so much being admitted, it seems impossible to stop short here. The continuity of moraines and of the effects of attrition seems to connect the vast deposits of the blocks of Monthey in the Valley of the Rhone below St Maurice with the undoubted glacier deposits of the Valleys of Trient and Ferret; and the blocks of Monthey cannot reasonably have any origin ascribed to them, which must not be extended by precise parallelism of circumstances to the innumerable forests of primitive boulders which once strewed the whole plain of Lower Switzerland, and which, reaching the Jura Mountains (formed entirely of limestone), has left an imposing memorial of its existence, in the vast belt of granitic masses, but slightly worn or rounded, which lie along the face of that chain facing the Alps, at a height of 800 feet above the Plain of Switzerland and the Lake of Neufchatel.[4]

Startling and improbable as such an origin must be admitted to be at first sight, it is found, upon examination, that every other hypothesis yet proposed to explain so important and striking a geological phenomenon is pressed with not less formidable difficulties. The reader who would see this question discussed in a manner which can alone render him competent to come to a just conclusion on the subject, must consult the original paper of Venetz already quoted, but more particularly the masterly essay of M. J. de Charpentier on the Erratic Phenomenon, being the second part of his *Essai Sur les Glaciers*. From this last named work we have borrowed a map (fig. iv.), showing (with as much accuracy as was known at the time, subject, however, to considerable modifications in detail) the boundary of the *Ancient Glacier of the Valley of the Rhone*, comprising its numerous tributaries, as indicated by the *extreme* limits of distribution of angular blocks which have been *mineralogically identified* with those found *in situ* in the chain of valleys which *debouche* into the Rhone Valley.[5]

EXPLANATION OF THE FIGURES.

Figure I. is a map of the chain of Mont Blanc, extending from the neighbourhood of the Col de Bonhomme to the Col Ferret. The basis is Raymond's map; but nearly all the eastern part is taken from Professor Forbes' survey of the Mer de Glace and its tributaries. The object of it is to show the origin and termination of the different glaciers. For this purpose the more palpable oversights of Raymond's map have been in some measure corrected, but much is still confessedly imperfect.

Figure II. is an outline of the principal glaciers of the Bernese Oberland, chiefly taken from the old map of Weiss. Some additions and corrections have been made; but, at the best, it is a rude and imperfect representation of the natural features, even in the more accessible parts, such as the neighbourhood of Grindelwald, but no better exists at present, nor is likely to do so before the still remote completion of the Swiss Government survey.

Figure III. is a reduction, in outline, of part of Professor Forbes' map of the Mer de Glace of Chamouni. It is intended to illustrate, 1*st*, The general form of the more accessible part of that glacier, and the position of its moraines; 2*d*, The exact form and distribution of those remarkable lines on its surface called the *Dirt Bands*, which are more accurately laid down than they have hitherto been; 3*d*, Profiles of the glacier, as seen in section, are introduced at different points of its length; 4*th*, The approximate annual motion of the ice, at different points referred to by letters, is shown to the eye by arrows of various lengths; the numbers alongside of which give the annual progress in English feet; of these, the points C, P, S, and T, are the best determined. The slope of this glacier is shown in figure V.

Figure IV. is taken without alteration from M. de Charpentier's *Essai sur les Glaciers*, and shows the approximate distribution over the surface of Switzerland of erratic blocks which had their origin in the Valley of the Rhone. The tinted part, which includes the boundaries of this erratic deposit, indicates, according to Charpentier, the space once covered by the Glacier of the Rhone. Its limits are, no doubt, subject to corrections, some of which have been pointed out by Mr Guyot, in a paper in the *Bibliotheque Universelle*, but the map as it stands represents well the general phenomena. The extreme height of the erratic formation, at different points, is marked in the plate on the authority of De Charpentier, and Elie de Beaumont.

Figure V., already referred to, shows the actual mean slope of the Mer de Glace of Chamouni, for different portions of its length.

Figure VI. is a graphic representation of the height of the snow line in different latitudes, and in both hemispheres. It is chiefly founded on the authorities cited by Humboldt in the third volume of his "Asie Centrale." It is sufficiently evident that a curve drawn through the points where perpetual snow commences, does not tend to reach the level of the sea in the Northern Hemisphere, though it does in the Southern.

Figures VII., VIII., IX., X., represent the four classes into which glaciers may be divided. Figure VII. is a sketch du Glacier de Miage, representing the class of *canal-shaped* glaciers or those having tolerably uniform breadth, and few tributaries. Figure VIII. gives an idea of an oval glacier, illustrated by that of Allalein Glacier in the Valley of Saas. Figure IX., or the *basin-shaped* glacier, is a reduction of Professor Forbes' map of the Glacier de Talèfre. Figure X. is a sketch of a glacier of the second order of De Saussure, illustrated by the small and elevated Glacier of the Schönhorn behind the Simplon Hospice.

[1] See Travels, &c., chap. viii. and xvi.

[2] See a remarkable example above referred to in the Glacier of La Brenva.

[3] See Agassiz' Atlas, plates viii. and xv.

[4] The vignette of fig. iv. represents the *Pierre à Bot*, one of the blocks of Monthey. The *Pierre à Bot*, 800 feet above the Lake of Neufchatel, is formed of *granite (protogine)* of the chain of Mont Blanc, which is distant, in a *right line*, seventy-five English miles. The dimensions of this stupendous stone are, according to Von Buch, 50 × 20 × 40 French feet, containing, therefore, 40,000 cubic feet.

[5] See further on this subject, Playfair's Illustrations of the Huttonian Theory, art. 343, and Works, vol. i. 98. Agassiz' Etudes sur les Glaciers, chap. xviii. Edinburgh Review for April 1842. Travels in the Alps of Savoy, &c., chap. iii. I cannot help adding, now that the existence of ancient glaciers has been so prominently brought forward as an explanation of geological phenomena in our own country, that I find that my excellent and learned friend, Professor Jamieson, was in the habit of stating in his lectures the possibility of such a geological cause. This is established by notes taken by myself when I had the advantage of being a student in his class in 1822.

THE PHENOMENA OF VOLCANIC ACTION,

AS EXEMPLIFIED IN

THE REGIONS VISITED BY EARTHQUAKES,

AND

THE DISTRIBUTION OF VOLCANOES OVER THE GLOBE.

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I. OUTLINES OF VOLCANIC PHENOMENA.

a. THE PHENOMENA OF EARTHQUAKES.

The object of the annexed map is to represent graphically, according to geographical distribution and extension, the influence which the reaction of the interior fires of our planet exercises on its crust and surface, as exemplified in the regions of earthquakes, and the distribution of volcanoes over the globe. Before entering on the geographical explanations, however, it may be useful, shortly, to inquire into the nature and extent of volcanic action. In the following sketch, in which the subject will be examined rather in a physical than a geognostical point of view, we shall be guided chiefly by the comprehensive and luminous representations of Alexander von Humboldt.[1]

Earthquakes and volcanoes, which stand in intimate connection with one another—the latter being, to some extent, the result of the former—are to be considered as the remains of great geognostical revolutions of our globe, previous to historical times, rarely changing the place of their appearance, and becoming active at intervals of time varying from an hour to a hundred years. We shall treat of them according to the above mentioned relations, and in their transition from a purely dynamic concussion, as evinced in the upheaving of entire continents and mountain masses, to the production and effusion of thermal springs, the escape of gaseous and sulphureous vapours, the eruptions of mud, and the more awful phenomena of burning mountains. The germ of all these phenomena—the origin of moving power—is to be sought for in the depths of the earth, in its temperature increasing with distance from the surface. But at what depth a lava-producing heat may be found is a question towards the elucidation of which modern research has only supplied materials for an uncertain approximation.[2]

The *Concussions of Earthquakes* consist in more or less violent commotions of particular parts of the surface of the globe. These are often so slight as only to be perceived by those accustomed to the phenomena, in which case there remains no visible mark of their activity. Sometimes, however, they produce violent convulsions of the earth, which, in their destructive effects, transmit lasting memorials to future generations. These concussions are of a threefold character; they are distinguished by a series of *perpendicular*, *horizontal*, or *undulatory* and *rotatory* motions, which follow each other in rapid succession.[3] The perpendicular mine-like explosion, acting from below upwards, was exhibited in the most striking manner during the destruction of Riobamba in 1797, when the bodies of many of the inhabitants were thrown upon a hill several hundred feet high. The horizontal vibration acts apparently in an undulating manner, causing an alternate rising and sinking of the earth in the direction of its course. Rotatory or circular concussions are the most rare, but most destructive of all, often following several cross directions, and causing a whirling movement of the earth, by which buildings, without being overturned, are twisted, parallel rows of trees are deflected, and fields, covered with different kinds of grain, are made to change their positions. This last movement, which is only observed to occur in the greatest earthquakes, was conspicuous in those of Lisbon and Calabria, the regions of which are represented on the map. Dolomieu, who gives a detailed account of the latter, says,[4] that the best idea of this undulating and springing motion may be obtained by placing small cubes of moist clay and sand near each other on a table, and communicating to them a vertical stroke from below, and as the same time moving the table horizontally from side to side.

The Progression of Earthquakes occurs most frequently in a linear direction, undulating with a velocity of from twenty to thirty geographical miles in a minute; sometimes it is in concussion circles or great ellipses, in which, as from a centre, the vibrations extend with decreasing force towards the circumference. One of the finest examples of linear progression was afforded by the great earthquake of Guadeloupe in 1842, which, within a space of from sixty to seventy miles in breadth, was observed over an extent of three thousand miles in length. The second kind of motion was exemplified in the great earthquake of Calabria in 1783, when the small town of Oppido formed the centre of a circle round which, within a radius of twenty-two miles, all the towns and villages were overthrown and destroyed.

The Duration of Earthquakes is, in proportion to the effects which they produce, exceedingly short; and it appears almost as if the amount of the one stood in inverse ratio to the other. The most destructive shocks are generally over in a moment. During the great earthquake of Caracas, by which ten thousand lives were sacrificed, and a flourishing province was reduced to ruins, three terrific shocks, each of which lasted from three to four seconds, followed each other within the space of fifty seconds; and the great earthquake of Lisbon, during which sixty thousand persons perished, lasted only about six minutes. The horror of these frightful visitations is greatly increased when they happen suddenly, without any warning of their approach; usually, however, great shocks are preceded by slighter vibrations of the earth, and by subterranean detonations.

These *Detonations*, which generally accompany an earthquake, but which do not increase in proportion to the strength of the vibrations, have been compared to the roll of thunder, the rattling of heavy waggons over a stone pavement, to the discharge of cannon at irregular intervals, or the hollow sound of an exploding mine. This noise is sometimes heard as distinctly at a great distance from the scene of an eruption as in its immediate vicinity, and, as has been well ascertained, at precisely the same moment of time. Hence it is inferred that the sound could not have been propagated through the air, since in that medium observation shows that a certain portion of time is required to transmit it from one station to another. Solid bodies are the best conductors of sound, which is transmitted through baked clay with a velocity ten or twelve times greater than through the open air. But as the known laws of acoustics are insufficient to account for this phenomenon, it is conjectured that the sounds must have originated in the interior of the earth at a nearly equal distance below the surface at all the places where they were observed. In Caracas, in the grassy plains of Calabozo, and on the banks of the Rio Apure, there was heard, on the 30th April 1812, without any appearance of an earthquake, a sound resembling a loud peal of thunder, at the moment when, at the distance of seven hundred miles to the north-eastward, the volcano of St Vincent discharged from its crater an immense stream of lava. It is remarkable that these sounds are often heard during a considerable period of time, without any earthquake taking place; for example, in the Dalmatian Island, Meleda (twenty miles from Ragusa), such detonations occurred from March 1822 till September 1834, almost without any movement of the earth, and A. von Humboldt has satisfactorily shown that the great shock in the earthquake of Riobamba (4th February 1797)—one of the most frightful phenomena in the physical annals of our globe—was not accompanied by any noise whatever. But the most remarkable instance of uninterrupted subterranean noise, without any appearance of an earthquake, is the occurrence of the phenomenon which is known in the highlands of Mexico under the name of the bellowings and underground thunders (bramidos y truenos subterraneos) of Guanaxuato. Under this celebrated and rich mining town, which is situated far from any active volcano, the sounds continued for a month, and neither on the surface of the earth, nor in the mines, sixteen hundred feet deep, was there the slightest appearance of an earthquake.

It is one of the undoubted characteristics which the phenomena of earthquakes still forth, that while they have their seat deep in the interior of continents, they also communicate, in the most remarkable manner with the sea. Wherever great earthquakes occur on coast-lands they are accompanied by violent agitations of the adjoining sea. During the earthquake of Lisbon, the sea rose to a height of fifty feet above its ordinary level. In the open ocean, the effect upon a ship resembles that produced by striking upon a rock under water. The effects of earthquakes on the waters of a continent are manifested in the rising and falling of lakes, the interruption of springs, &c.

Although an earthquake appears, at first sight, to be only a dynamic motion connected with space, yet we know, from the most positive experience, that it not only has the power to raise vast tracts of land above their former level (as, for example, Ullah-Bund, after the earthquake of Catch, and the coast of Chile, to an extent of one hundred thousand square miles), but also that during the concussion, hot water, steam, mephitic gas, mud, black smoke, and even flames, have been discharged. A. von Humboldt[5] has touchingly described the impressive, and entirely peculiar effect which the experience of an earthquake, for the first time, produces upon the observer: "From early childhood," he says, "we are accustomed to contrast the mobile element of water with the immobility of the soil on which we stand. All the evidences of our senses have tended to confirm our belief in this contrast; but when suddenly the soil begins to heave, the sense of some unknown mysterious natural power, acting upon and moving the solid globe, seizes upon the mind, and in a moment the illusion of the whole of our earlier life is annihilated."

That the great phenomenon of the slow, imperceptible *raising* and *sinking* of whole continents (as exemplified especially in Scandinavia and Greenland), which in recent times has attracted the attention of the entire geological world, does not come under the category of that partial upheaving of countries, caused by the more concentrated shocks of earthquakes, is evident. We only know that the active cause is subterranean, and therefore the extent of these phenomena could not, with propriety, be omitted in a map which treats of the geographical distribution of the effects of subterranean forces. We shall therefore recur to the subject afterwards.

[1] A. von Humboldt's "Kosmos," German edition, band i., s. 209-257.

[2] The phenomena of volcanoes and hot springs led to the belief, prevalent among philosophers since the earliest times, that there exists a central heat in the globe; and the numerous observations made in mines, which, however, only extend to a depth of from 1,000 to 1,200 feet, have confirmed this opinion, although the results of these observations, in consequence of the presence of the miners with their lamps or candles, the explosion of gunpowder, the admixture of external air, and other causes, are not satisfactory. M. Cordier, who collected all these observations previous to 1827, is of opinion that the increase would not be overstated at 1° Cent. for every 25 metres, or about 1° Fahr. for every 45 feet, a result which is supported by the high temperature of water in Artesian wells, since the careful observations in the well of Grenelle, of M.M. Arago and Walferdin give an increase of 1° Cent. for every 31 or 32 metres.—Berghaus' *Länder* und Völkerkunde, ii., s. 773. See also a notice by Mr Taylor, on the temperature of the earth and sea, in the *Athenæum*, February 28, 1846.

[3] Besides the three above noticed characteristics of concussions, a fourth kind is frequently described as tremulous shocks, termed trembleurs by the inhabitants of the countries of South America, where they occur very frequently. These are the least destructive in their effects, and generally last only a few seconds, although sometimes they continue at intervals for several days together.

[4] Berghaus' Geographischer Atlastasch, 1837, p. 46. See also in same vol., pp. 1-171, and in that for 1839, pp. 1-105, two valuable treatises on Volcanic Phenomena by an anonymous writer.

[5] Kosmos, band i., s. 274.

THE PHENOMENA OF VOLCANIC ACTION

Showing the Regions visited by

EARTHQUAKES

AND THE

DISTRIBUTION OF

VOLCANOES

OVER THE GLOBE.

BASED ON THE DESIGNS OF PROFESSOR BERGHAUS.

BY A. K. JOHNSTON, F.R.G.S.

EXPLANATION.

The names of Volcanoes & Earthquake districts are distinguished from topographical names &c by bold letters, thus LINEAR VOLCANOES, Central Crots, *Single Volcanoes Earthquake districts etc.*

The names of active Volcanoes are generally larger than those which are extinct or doubtful.

The regions visited by Earthquakes are distinguished by shading which is darker in proportion to the force and frequency of the shocks. The extension of some inevitable Earthquakes is shown by lines, the first of which, surrounding a dark spot shows the extent of devastation, the coloured lines express the extent of perceptible concussion or detonation.

The figures placed beside the names of Volcanoes express their height in feet.

Signs of the various phenomena.

- Central groups or Volcanoes
- Active Volcanoes
- Extinct Volcanoes
- Ho shan. Fire Hills. } of China
- Ho hsing. Fire Wells. }
- Solfataras, Warm Springs etc. of Central Asia
- Submarine Eruptions
- Showers of Volcanic Ashes
- Lava Streams
- Raising of Land
- Sinking of Land
- Where uncertain thus
- Doubtful Volcanoes

ENLARGED MAP OF THE PRINCIPAL VOLCANIC SERIES OF THE NEW WORLD.

Scale. Three times larger than the General Map.

ENLARGED MAP OF THE PRINCIPAL VOLCANIC SERIES OF THE OLD WORLD.

Scale. Three times larger than the General Map.

ICELAND

Chiefly according to Krug von Nidda.

The small figures in parentheses show the date of the latest eruption of the Volcanoes.

Scale 1:600,000

EAHEINOMAUWE (NORTH I. OF NEW ZEALAND) by Leopold von Buch

Scale 1:6,000,000

HAWAII ARCHIPELAGO OR SANDWICH ISLANDS

Scale 1:10,000,000

CANARY ISLANDS

Scale 1:6,000,000

GREEK ISLANDS

According to Leopold von Buch

Scale 1:6,000,000

VOLCANIC DISTRICT OF LOWER ITALY

Scale 1:2,000,000

NOTE.

This important Volcanic circle, as newly discovered by P. Earthquake, was added to the Map after the letter-press was printed, consequently several Volcanoes are omitted in the table P. 3.

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A. K. Johnston.

(Active Volcanoes distinguished by a star, thus *). c. GEOGRAPHICAL DISTRIBUTION OF VOLCANOES OVER THE GLOBE. (Volcanoes of doubtful activity, thus ? *—Vs. of doubtful existence, thus ? ?).

SYSTEMS.	VOLCANIC SERIES.	Geographical Position. Latitude.	Geographical Position. Longitude.	Date of last Recog. Erupt.	Height in Eng. feet.
	CENTRAL GROUPS.				
	A. MEDITERRANEAN SEA.				
I. Etna, . . .	* 1. Etna in Sicily. (Maccaluba, Mud V. in the SW. part of Sicily).	37° 45' ° N.	14° 59' ° E.	1852	10,874
II. Vesuvius, . . .	* 2. Vesuvius at Naples. (Vesuvius in the I. of Ischia, extinct V.).	40. 49. 40 .	14. 27. 18 .	1846	3,710
III. Lipari Is, . . .	* 3. Stromboli in the I. of Stromboli, . . .	38. 47. 30 .	15. 13. .		2,917
	* 4. V. of Volcano I., . . .	38. 24. .	14. 57. .		
	B. ATLANTIC OCEAN.				
IV. Jan Mayen, . . .	* 5. Mt. Beerenberg (Beerenberg) or Esk, in the I. of Jan Mayen,	70. 49. .	7. 31. W.		6,870
	* 6. Volcano of the Egg or Red's Island, . . .	70. 30. .	8. 40. .		
	* 7. Loudenkar, . . .	65. 47. .	18. 48. .	1720	
	* 8. Krafla, . . .	65. 45. .	16. 42. .	1724	
	* 9. Trolladyngar, . . .	63. 30. .	18. 44. .	1310	
V. Iceland, . . .	* 10. Hurdubreid, in the I. of Lassansche, . . .	65. 21. .	16. 30. .	1717	
	* 11. Oraefa Jokul, . . .	64. 10. .	16. 55. .	1783	5,397
	* 12. Hekla. (The Geysers are situated north-west of Mt. Hekla).	63. 58. .	19. 45. .	1845	5,110
	* 13. Kotlugia or Myrdals Jokul, . . .	63. 38. .	19. 25. .	1823	
	* 14. Eyafialla or Oester Jokul, . . .	63. 37. .	19. 37. .	1821	
VI. Azores, . . .	* 15. El Pico in the I. of Pico, . . .	38. 36. .	28. 28. 30	1720	7,890
	16. V. of the I. Fayal or Fleo, south of S. Miguel, . . .	38. 32. .	28. 42. .	1672	
	* 17. Pico de Teyde, in the I. of Teneriffe,	28. 17. 49 .	16. 39. 15 .	1798	12,182
	18. Pico de Chahorra,	28. 16. 30 .	16. 37. 45 .	1730	9,350
	19. Mts. de las Cabras in the I. of Palma, . . .	28. 42. 30 .	17. 54. .	1677	
VII. Canary Is., . . .	20. Vendaya in the I. of Gran Canaria, . . .	28. 08. .	15. 41. .		4,331
	21. Mts. de Atalaya in the I. of Fuerteventura, . . .	28. 40. .	13. 54. .		
	22. Mts. de Fuego in the I. of Lanzarote, . . .	29. 01. 03 .	13. 46. .	1730	
	23. V. of the I. Alegranza, . . .	29. 25. 30 .	13. 29. 30 .		870
VIII. Cape Verde Is.	* 24. V. of the I. Fuego or Fogo, . . .	15. .	24. 22. .	1847	9,157
IX. Ascension I.	25. I. Ascension. (Green Mt. 2,810 feet high,) . . .	7. 57. . S.	14. 25. .		
X. Tristan da Cu. Is.	???? 26. V. of Tristan da Cunha I., . . .	37. 6. .	12. 18. .		8,230
XI. Trinidad I., . . .	27. V. of the I. Trinidad, . . .	20. 31. .	29. 52 .		
XII. Travers Is., . . .	* 28. V. of the Travers Is., . . .				
	C. INDIAN OCEAN.				
	* 1. V. of the I. of Bourbon, . . .	20. 55. .	55. 29. . E.		8,250
XIII. Bourbon, &c.,	? ? 2. Mts. of the I. of Mauritius, . . .	20. 12. .	57. 30. .		
	? ? 3. V. of the I. of Rodriguez, . . .	19. 41. .	63. 26. .		
	D. PACIFIC OCEAN.				
	? ? 1. Mauna Kea or Mowna Kea, . . .	19. 50. N.	155. 39. W.		13,845
	* 2. Mauna Wororoay or Hualai, . . .	19. 44. .	155. 50. .		10,700
XIV. Hawaii Archipelago,	* 3. Mauna Loa Loa or Great Mountain, in the I. of Hawaii,	19. 29. .	155. 35. .	1843	13,760
	* 4. Kilauah or Great Volcano, . . .	19. 25. .	155. 27. .		4,270
XV. Galapagos Is., . . .	* 5. V. of Narborough, . . .	0. 30. . S.	91. 30. . W.	1825	3,720
XVI. Marquesas Is., . . .	? ? 6. V. of Domenico or Ohivahoa, . . .	9. 43. .	139. 54. .		? 3,000
XVII. Society Is., . . .	? ? 7. Volcanoes in the I. of Otaheite, . . .	17. 30. .	149. 30. .		? ? 12,000
XVIII. Easter I., . . .	8. V. of Easter I., . . .	27. 06. 29 .	109. 15. 52 .		1,200
	E. ASIATIC CONTINENT.				
	* 1. Demavend (Coloneh or Koh-i-Demawend, in Elburz Mts.), . . .	35. 56. . N.	52. 11. . E.		14,025
XIX. West Asia, . . .	? ? 2. Ararat, . . .	39. 42. .	44. 35. .		17,210
	? ? 3. Sultan Dagh, or Sepan Tagh, north of Lake Van, . . .	38. 35. .	42. 48. .		

SYSTEMS.	LINEAR VOLCANIC SERIES.	Geographical Position. Latitude.	Geographical Position. Longitude.	Date of last Recog. Erupt.	Height in Eng. feet.
	A. OLD WORLD.				
I. Greek Is., . . .	* 1. I. Santorini, . . .	36. 23. .	25. 30. . E.		
II. Teneriffe, . . .	* 2. Peaden, . . .	42. 56. .	23. 53. .	?1600	
	* 3. V. of Hetchlem, . . .	43. 15. .	30. 35. .		
III. Red Sea, . . .	* 4. Jebel Tier, Tore, or Zore, also J. Deshan,	27. 58 .	41. 35. .	1824	895
	5. V. of the Is of Salsette or Zebayt. (? Sagole & Harnish In. Volc.).	15. 02. .	42. 17. 15 .		
	6. V. of the I. Tuba, . . .	20. 16. .	37. 35. . W.		? 3,000
IV. Friendly Is., . . .	* 7. V. of the I. Amargura, . . .	17. 57. .	174. 30. .		
	* 8. Ngauruhoe in the northern Island of New Zealand,	39. 10. .	175. 13. . E.		
	9. Edgecombe in the White I. (Bay of Plenty), . . .	38. 09. .	177. 02. .		8,029
	* 10. V. of Monument Island (according to Capt. Thayer), . . .	30. 14. .	178. 55. .		
	* 11. Mathew, or Matthew, . . .	22. 22. .	171. 15. .	1829	
	* 12. V. of Aurora, in the New Hebrides, . . .	15. 30. .	168. 30. .	1774	434
	* 13. V. of Lopevi, on the same Archipelago, . . .	16. 15. .	168. 30. .		
	* 14. V. of Volcano I., in the Isles of Santa Cruz, . . .	10. 23. 30 .	166. 00. .		? 200
	* 15. V. on the New Britain, . . .	9. 46. .	148. 01. 30 .		? ? 3,000
	* 16. V. on the south-west coast of New Britain, . . .	5. 30. .	148. 30. .		
	* 17. V. on the south-east coast of New Britain, . . .	5. 35. .	149. 16. .		
	* 18. V. on the south-east coast of New Guinea, seen by Dampier,	5. 55. .	144. 15. 30		
	* 19. V. 12 miles from the northern coast of New Guinea . . .	3. 55. .	144. 15. 30		
	* 20. V. on the north-western point of New Guinea . . .	0. 30. .	130. 30. 30		
	21. Wewauti in the I. of Amboina, . . .	3. 40. .	128. 30. .		
	22. Gounong Api (Burning Mt.) of Banda I., . . .	4. 30. .	130. 05. .		? 4,000
	* 23. Serua, Sirua or Cureen, . . .	6. 30. .	130. 45. .	1693	
	* 24. V. of Wia I., . . .	6. 50. .	129. 30. .		
	* 25. Teon, . . .	7. 30. .	128. 30. .		
	* 26. Gounong Api, . . .	7. 30. .	127. 30. .	1820	
	? ? 27. V. of Cumbing or Pumpa I., . . .	8. 20. .	123. 30. .		
	* 28. V. of Puntar I., . . .	? ? 8. 20. .	123. 30. .		
	* 29. Gold Lombock, (Lombatta) I., . . .	8. 12. .	119. 42. .		
	30. Lobal Lombock, . . .	8. 35. .	119. 42. .		
	31. V. near the mid. of the Island, Volcanoes of Flores I.,	8. 45. .	121. 30. .		
	32. V. near the southern coast, . . .	? ? 8. 52. 30 .	121. 30. .		
	33. V. of Flower Island, south of Flores, . . .	8. 50. .	120. 30. .		
	? ? 34. Coad Island, . . .	8. 50. .	120. 00. .		
	? ? 35. Bale Combe, Probable Vols. of the southern coast of Celebes,	5. 50. .	120. 00. .		
	? ? 36. Bent Island, . . .	5. 40. .	120. 00. .		
	* 37. V. of Jindana or Sandalwood I., . . .	9. 30. .	118. 15. .		
	? ? 38. V. of Jillonata I., . . .	9. 30. .	119. 12. .		
	* 39. Gounong Api, in a small island near the NE. point of Sandawa,	9. 11. .	118. 45. .		
	* 40. Tomboro or Arjon Mt. in the I. of Sandawa, . . .	8. 01. 30 .	118. 00. .	1815	? 7,000
	* 41. V. of Lombock I., . . .	8. 21. 30 .	116. 30. .		? 5,000
	? ? 42. Kara Assano or Salt Peak, in the I. of Bali, . . .	8. 20. .	114. 30. .	1843	3,748
	? ? 43. Ujong or Tamberra, . . .	7. 58. .	114. 12. .	1817	5,000
	44. Klappa, . . .	7. 55. .	113. 42. 30 .		
	* 45. Lamongan, . . .	7. 50. .	113. 21. .	1090	4,676
	46. Semeru, . . .	7. 50. .	113. 00. .		12,000
	* 47. Bromo, . . .	7. 56. .	113. 00. .	1804	7,604
	* 48. Wallerang, . . .	7. 43. .	112. 52. .		10,500
	49. Arjuno, . . .	7. 50. .	112. 30. .		11,541
	* 50. Kloh, . . .	7. 56. .	112. 15. .	1760	7,000
	51. Welirang, . . .	7. 45. .	112. 15. .		10,000
	52. Lawu, . . . Volcanoes	7. 38. .	111. 30. .		10,772
	53. Dieparis, . . .	7. 30. .	110. 45. .	1772	8,700
	* 54. Merapi, . . .	7. 30. .	110. 30. .	1822	10,000
	55. Merbabu, . . .	7. 30. .	110. 30. .		11,000
	56. Ungarang, . . .	7. 05. .	110. 00. .		7,500
	* 57. Sumbing or Sumbing, . . .	7. 05. .	110. 00. .		11,200
	* 58. Sindoro or Sudoro, . . .	7. 10. .	109. 56. .		9,858
	* 59. Slamat, Gedeh or Tegal, of the	7. 10. .	109. 08. .		11,200
	The following Vols. form a distinct Series:—				
	a. Northern Series.				
	* 60. Tjerimai or Tchermai, . . .	6. 53. .	108. 28. .	1800	8,999
	61. Gounong Kaja, . . .	7. 05. .	108. 14. .		6,400
	62. Arang, . . .	6. 57. .	107. 54. .		
	63. Dekit Upichang, . . . Island	6. 54. .	107. 48. .		
	64. Mangkupang, . . .	6. 46. .	107. 36. .		
	65. Bukit Tunjul or Tunggil, . . .	6. 51. .	107. 31. .		
	66. Guntur, . . .	6. 14. .	107. 51. .		
	* 67. Tarkuban Prahu, . . .	6. 45. .	107. 35. .	1699	6,672
	68. Bunnagrang, Bunagrang or Burungtang, . . .	6. 45. .	107. 11. .		4,000
	b. Southern Series.				
	* 69. Galung Gung, . . .	7. 15. .	108. 12. .	1822	9,000
	* 70. Talyra Bulung, of	7. 15. .	108. 07. .		8,400
	71. Telchkurai or Telchura, . . .	7. 35. .	108. 05. .		8,340
	* 72. Papandayan, . . .	7. 50. .	107. 54. .	1772	8,000
	73. Wayang or Wyhan, . . .	7. 55. .	107. 50. .		7,347
	74. Malabar or Malawar, . . .	7. 58. .	107. 46. .		7,500
	75. Sumbung, . . .	7. 58. .	107. 40. .		8,000
	76. Tilu, . . .	7. 58. .	107. 34. 30 .		7,000
	* 77. Patuha, Badiwa or Pulacha, . . .	7. 15. .	107. 30. .		7,967
	78. Tankuk-rayung or Tankuk Payung, . . . Java.	6. 53. .	107. 30. .		7,000
	* 79. Gedeh. (This Volcano unites the two series.) . . .	6. 53. .	106. 58. .		9,959
	80. Salak, . . .	6. 44. .	106. 45. .	1761	7,784
	81. Gegik, . . .	6. 45. .	106. 30. .		
	82. Karang or Galgatha, . . .	6. 21. .	107. 30. .		8,383
	83. Djali or Djale, . . .	6. 18. 30 .	106. 57. .		
	84. Pulasare, . . .	6. 13. .	106. 55. .		
	85. Dyanging, . . .	6. 13. .	106. 55. .		
	* 86. V. of the I. Cremation or Rokata, . . .	6. 06. .	105. 26. .	1680	
	* 87. Gounong Dempo, . . .	3. 54. .	103. 09. .		12,000
	* 88. Gounong Api or Berapi, . . .	3. 46. .	101. 46. .		8,000
	89. Merapi, or Berapi, . . .	0. 09. .	100. 43. .		13,000
	* 90. Singalang or Sirkalang, . . . Vs. of the I. of Sumatra,	0. 11. .	100. 33. .		13,000
	* 91. Gounong Pasaman or Ophir, . . .	0. 05. . N.	99. 57. .		12,840
	92. Batogagih, . . .	0. 42. .	99. 45. .		
	? ? 93. Mt. Elephant or Prior's Head, . . .	0. 07. .	98. 58. .		
	* 94. V. of Barren I., . . .	? ? 10. 20 .	93. 50. .	1795	1,200
	95. V. of Narcondam I., . . .	13. 24. .	94. 20. .		
	96. V. of I. Regnata, . . .	13. 57. 30 .	93. 46. 30 .		50
	97. V. of Cheduba I., . . .	18. 50. .	93. 26. .		
	* 98. V. of Sanoro I., . . .	19. 45. .	92. 46. .		
	The 2 following are Isolated				
	* 99. V. of Cape L., between New Guinea and Australia—(perhaps prolongation of the Sunda series).	8. 48. .	S. 142. 38. .		
	* 100. V. of Barrving I., on the S.W. shore of Borneo, . . .	3. 20. .	108. 30. .	1703	
	* 1. V. of the I. Macklott, . . .	8. 10. .	127. 30. .	1646	
	* 2. V. of the Moltz, . . .	8. 20. .	127. 54. .		
	* 3. V. in the southern part of Tibra I., . . .	8. 26. .	127. 54. .		
	* 4. V. of Bonna I., . . .	8. 30. .	127. 54. .	1814	4,955
	* 5. V. at Gunnemanarre in the I. of Gilolo, . . .	0. 42. .	127. 54. .	1673	
	* 6. Volo of the I. Morree, . . .	0. 30. .	127. 54. .		
	* 7. Klobet at Kema in the N.E. part of Celebes, . . .	1. 25. .	125. 18. .	1690	
	? ? 8. V. of Bonra I., . . .	1. 45. .	125. 18. .		
	? ? 9. V. of Bujaree I., . . .	2. 06. .	125. 18. .		
	? ? 10. V. of Tagulanda I., . . .	2. 30. .	125. 30. .		
	* 11. V. of Siao I., . . .	2. 43. .	125. 20. .		
	* 12. Aba in the northern part of the Sangire I., . . .	3. 43. .	125. 30. .	1711	
	* 13. Sangeili, in the district Sesangani . . . Vs. of Mindanao I.,	3. 44. .	125. 18. .	1704	
	* 14. Tamboro, in the N.E. of Sea Augustin . . .	3. 50. .	125. 30. .		
	15. Dano or Sutoli, near the Lake Lano . . .	3. 26. .	124. 24. .	1646	
	16. V. of the I. of Sanguir, . . .	3. 46. .	125. 30. .		
	* 17. Bulusan . . .	12. 47. .	124. 47. 45 .		
VII. Moluccs Is., Philippine Island, and Formosa,	18. Albay or Mahon . . .	13. 20. .	123. 45. 30 .	1814	
	* 19. Mascoras . . . Volcanoes	14. 31. 30 .	123. 43. .		
	20. Buji . . . Volcanoes	14. 30. .	123. 15. .		
	* 21. Yaqui, . . . of the Prairie. of	13. 24. .	123. 35. 30 .		
	* 22. Yaeng . . . Camarines, Island	13. 50. 30 .	123. 45. 30 .		
	* 23. Cobak . . .	13. 55. 30 .	123. 12. .		
	* 24. Lobo . . .	14. 00. .	122. 55. .		
	* 25. Bacoory . . . of	14. 10. 30 .	122. 52. 30 .		
	* 26. Bonsoll . . . Luzon,	14. 03. .	122. 44. 30 .		
	* 27. Bosoojan de Taytan, . . .	14. 03. .	121. 02. .		
	28. Taal in the Lake Tabi, . . .	14. 00. .	121. 00. .	1754	
	? ? 29. Arayat or Arayan—(perhaps Monte de San Tomas)	14. 12. .	120. 49. .	1641	
	? ? 30. Aringay, . . .	16. 15. .	120. 30. .	1640	
	31. V. of Amlit, W. of Lintin, . . .	13. 45. .	120. 23. .		
	* 32. V. of Cartigula I., . . .	16. 25. .	121. 35. 45 .		
	* 33. V. near the Bashy Islands, . . .	19. 27. .	122. 02. 15 .	1831	
	* 34. Tobykang (= Red Mountain), . . .	22. 07. .	120. 35. .		
	? ? 35. Pico nan ny chan, . . . Vs. of I. Formosa,	22. 37. .	120. 44. .		
	* 36. Ho chan (= Fire Mount), . . .	23. 10. .	120. 58. .		
	* 37. Lien hoang chan (= Brimstone Mount), . . .		127. 45. .		
	38. Long hoan chan or Sulphur I. in the Archipelago of Loo-choo,	26. 30. .	130. 40. .		
	? ? 39. V. of the I. of Tatsuga, . . .	30. 30. .	130. 30. .		
	* 40. V. of Jesso chan or Brimstone Island, . . .	30. 45. .	130. 15. 29 .		
	* 41. Asso no yama, in the district Aso of the prov. Figo, Vs. of the I. of Kiusiu,			1792	
	* 42. Un sen go dake, . . . dake, Takaku, prov. Figen			1793	
	43. Riwo no kuni, . . .			1793	
	* 44. Miyi yama, . . .			1038	
VIII. Japan, . . .	* 1. V. near the I. of Firando, near N.W. point of Kiusiu,	34. 30. .	130. 01 .	1792	? 2,000
	* 2. Pasi no yama, in the prov. Iwo, . . .	34. 40. .	130. 32. .	1781	
	* 10. V. of the I. Ou chima or Yeso, . . .	41. 40. .	139. 30. .		
	* 11. V. of the I. Naki sima, . . .	41. 01. 30 .	139. 34. .		
	* 12. Sira yama (= White Mount), . . . Vs. of the I. of Niphon,				
	* 13. Asama yama or Asama no dake, . . .	36. 15. .	140. 10. .	1783	
	* 14. Peak Tilesius, . . .	44. 57. .	149. 10. .		
	* 15. Tosan, . . .	40. 03. .	143. 00. .		

SYSTEMS.	VOLCANIC SERIES—continued.	Geographical Position. Latitude.	Geographical Position. Longitude.	Date of last Recog. Erupt.	Height in Eng. feet.
VIII. Japan—continued.	* 16. Yake yama, in the prov. Mats, Vs. of the I. of Niphon,	41° 52' ° N.	141° 52' ° E.		
	* 17. V. of Kos sima I., . . .	41. 21. 30 .	139. 40. .		
	? ? 18. V. of Oo sima I., . . .	41. 31. 30 .	139. 35. .		
	* 19. Usu-san, . . .	42. 30. .	140. 55. .		
	* 20. On nat yama, . . . Vs. of the I. of Yeso,	42. 00. .	140. 56. .		
	* 21. Ten ga-take, . . .	42. 37. .	140. 56. .		
	? ? Yenkoi or Ghinam, . . .	43. 45. .	141. 30. .		
	? ? 22. Peak of South Sikkine I., . . .	46. 30. .			5,350
	? ? 1. Anton's Peak or Tchutchanchari in the I. of Kunashir,	44. 21. .	145. 46. .		
	? ? 2. V. of the I. of Tchikotan or Spanberg's I., . . .	48. 32. .	154. 30. .		
	* 3. V. of the I. Harup, . . .	45. 26. .	149. 00. .		
	4. V. of South Tchikotan I., . . .	46. 28. 15 .	150. 05. .		
	? ? 5. V. of Nyanchei or Broughton's I., . . .	46. 43. 30 .	150. 28. .		
	6. Daikke of Schismarike I., . . .	47. 02. 30 .	151. 30. .		
	? ? 7. V. of I. Uchichir, . . .	47. 32. 40 .	152. 16. 15 .		
	* 8. Pic Sarytschef in the I. of Matua or Matowa, . . .	48. 06. 09 .	153. 15. .		
IX. Kurile Islds.	* 9. V. of Rashoka or Rachkoke, . . .	48. 16. 20 .	155. 15. .		
	* 10. Demerka of the I. of Schiaschotan, . . .	48. 55. .	154. 00. .		
	11. V. of Harrou I., . . .	49. 09. .	154. 00. .		
	? ? 12. V. of Kharamokotan I., . . .	49. 30. .	154. 30. .		
	* 13. To orange, . . .	49. 24. .	154. 40. .		
	14. Anuke-sapre, . . . Vs. in the I. of Onekotan or Anakotan,	49. 32. .	154. 45. .		
	15. Antaracose, . . .	49. 40. .	155. 00. .		
	16. V. in the northern part . . . of the I. Paramoushir,	50. 00. .	155. 30. .		
	* 17. V. in the south-western part . . .	50. 15. .	156. 5. .	1793	
	* 18. V. of Alaid I., . . .	50. 52. .	155. 35. .	1827	
	* 1. Two Koriliss Volcanoes, . . .	51. 44. .	156. 51. .		
	* 2. Peak or Opalushala Sopka, or Kashalof, . . .	51. 30. .	157. 14. .		
	* 3. Gimaschkoi or Kolmiku, . . .	51. 58. .	157. 30. .		
	* 4. Assatchinskaia Sopka, . . .	52. 02. .	157. 43. .	1828	
	* 5. Five Wierchinskaia S. or Penzulnoi, also Five Mt.,	52. 20. 30 .	158. 30. .		7,890
	* 7. Opalusha S., . . .	52. 30. .	157. 30. .		
	* 8. Second Wilutchinskaia S., . . .	52. 47. 30 .	158. 30. .		6,746
	* 9. Kosheleva S., . . .	53. 15. 30 .	158. 30. .		
	10. Awatscha or Gorelaja S., . . .	53. 17. .	158. 43. .	1827	8,003
	* 11. Koriatskaja or Nimelenskaja S., . . .	53. 19. .	158. 44. .		11,300
	* 12. Schapanowska S., . . .	53. 30. .	158. 50. .		
	* 13. Ermakofska S., . . .	54. 40. .	160. 34. .		10,000
	* 14. Chitchagofska S., . . .	55. 14. .	160. 30. .	1843	13,710
	* 15. Tolbatchinskaja S., . . .	55. 31. 30 .	160. 00. 45 .	1730	9,300
	* 16. Fourth S., . . .	55. 40. .	160. 30. .		
	* 17. Udinskaja S., . . .	56. 00. 30 .	160. 30. .		11,772
	* 18. Kronotzkoi S., . . .	54. 46. .	160. 30. .		9,003
	* 19. Klutchewskaja, or Kamtchatkaja S., . . .	56. 04. 15 .	160. 30. 49 .	1828	15,565
	20. Schivelutch, north-western summit, . . .	56. 30. 24 .	161. 21. 22 .		8,240
	21. Schivelutch, north-eastern summit, . . .	56. 40. 32 .	161. 21. 22 .		10,546
	(Uninia, 4 vols. of Grass or Gushes, . . .	57. 00. .	161. 30. .		
	? ? 2. V. of Tittoo I., . . .	45. 02. .	146. 42. .		
	? ? 3. V. of Isle of Birds, or Pinchin de Medenilla, . . .	45. 02. .	146. 42. .		
	* 4. V. of Onglass I., . . .	45. 06. .	146. 10. 30 .		
	* 5. V. of Pagan I., . . .	45. 42. .	145. 00. .		
	6. V. of Grigan I., . . .	48. 18. .	145. 52. .		
	* 7. V. of Assonsole, Asumpcion, or Volcan Grande, . . .	48. 48. .	145. 45. .		7,000
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	* 2. V. of Great or Semisopochnoi I., . . .	51. 58. .	179. 45. .		? 3,000
	* 3. V. of Gotowa Gorod I., . . .	51. 47. .	178. 40. . W.		
	* 4. V. of Tanlga I., . . .	51. 57. .	179. 18. .		
	* 5. V. of Kinjgan I., . . .	52. 01. .	179. 30. .		
	6. V. of East Sitchin I., . . .	52. 00. .	178. 02. .		3,626
	* 7. V. of Kanaschtak I., . . .	52. 00. .	176. 17. .		
	* 8. V. of Kanaschtak I., . . .	52. 06. .	176. 12. .		
	9. Kiuchinskoi, . . . Volcanoes of the I. of Alaska,	52. 23. 42 .	174. 01. 18 .		
	* 10. V. of the NE. point . . .				4,012
	* 11. V. of Segnan I., . . .	52. .	172. 30. .		
	* 12. V. of Amaklon or Amaklok I., . . .	52. 03. .	171. 04. .		
	* 13. V. of Vanalga I., . . .	52. 40. .	170. 06. .	1830	
	14. Tchegulak, . . .				
XIII. Aleutian Islds.	15. Tchigulak, . . .				
	* 16. V. of Tanaik-Augmadi I., . . .				
	17. Kanaschtak, . . .				
	* 18. Wawidowskoi, . . . Volcanoes of Umnak I.,	53. 54. .	166. 46. .		
	* 19. Tschiloski, . . .	53. 30. .	167. 30. .		
	* 20. V. of Joanna Bogostawa I. or Aperbamkh, . . .	53. 00. .	167. 30. 23 .	1825	1,892
	* 21. Makuschinskoi, in the I. of Unalaschka, . . .	53. 54. .	166. 46. .		3,474
	* 22. V. of Akun I., . . .	54. 10. .	165. 55. .		2,300
	* 23. V. of Akun I., . . .	54. 20. .	165. 45. .		
	24. Schumagin, . . . This 4 others in Umnak	54. 46. .	160. 00. .	1826	6,856
	25. V. of the Sea Serwendel, . . .				6,000
	26. V. of the George I., (on of the Trifonoff Is.), . . .	56. 30. .	160. 10. .		
	27. V. of Ashinskoi I., . . .	55. 22. .	161. 45. .		
	28. Marchowsk, . . .		163. 00. .		
	29. Pawlowskoi, . . . Vs. of the Peninsula Alaska,		162. 30. .		
	30. Medwedskoi, . . .		162. 30. .		
	* 1. Glorioso, . . . Vs. W. of Cook's	60. 00. .	162. 00. .		12,000
	2. V. opposite the Redoute St Nicolaus I. Inlet, . . .	60. 45. .	152. 00. .		11,270
	3. Wrangell's V. at the River Atna, . . .	61. 30. .	143. 00. .		
	* 4. Mt. Elias, . . .	60. 17. 30 .	140. 31. 30 .		17,900
	5. Bona Tonga, . . .	61. 30. .	141. 00. .		15,000
XIV. North American Islands,	6. Bona Tonga, . . .	62. 46. 30 .	139. 45. 30 .		16,000
	7. Mt. Hudson or Jacinto in the I. of St Lazarus,	62. 45. .	139. 30. .	1790	9,000
	8. Mt. Hudson . . . Vs. near the River Columbia,	63. 00. .	139. 30. .		
	* 9. V. of St Helens . . .	46. 00. .	123. 00. .		
	* 10. Vs. of California, . . .	36. 00. .	119. 00. .	1746	
	* 11. V. of Colima, . . .	19. 30. .	104. 00. .		8,000
	* 12. Colima, . . .	19. 15. .	103. 45. .	1760	12,000
	* 13. Volcan, . . .	19. 10. .	104. 01. 45 .		8,265
	* 14. Tolima, . . .	19. 00. .	104. 00. .		15,100
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XV. Mexico,	* 16. Istaccihuatl (= White Woman), . . .	19. 10. .	98. 50. .		16,000
	* 17. Mitchs or Citlalepetl, . . .	19. 02. 18 .	97. 18. 13 .	1759	17,374
	* 18. Tuxtla, . . .	18. 30. .	95. 30. .	1793	
	* 19. Soconusco, . . .	15. 34. 30 .	93. 47. 40 .		12,100
	* 20. Vs. de las Antijos or Hamiltpas, Western Vs.	13. 34. 30 .	91. 51. 30 .		13,000
	21. Vs. de las Antijos or Quemalmango, Eastern Vs.	13. 34. .	91. 51. 30 .		
	22. Sapotillon, . . .	14. 46. 30 .	91. 40. .		
	23. Quemalmango, . . .	14. 46. .	91. 40. .		
	24. Atitlan, . . .	14. 42. .	91. 27. .		12,500
	25. Solomata, . . .	14. 42. .	91. 27. .		
	26. Acatenango, . . .	14. 30. .	91. 00. .		
	27. Agua, . . .	14. 30. .	91. 00. .		
	28. Fuego, . . .	14. 29. .	90. 57. 40 .		13,000
	29. Agua, . . .	14. 15. .	90. 58. .		
	30. Pacaya, . . .	14. 23. 30 .	90. 45. .		
	31. Isalco, Sonsonate or Teinlad, . . .	13. 46. .	89. 35. .	1825	4,500
	32. San Salvador, . . .	13. 40. .	89. 15. .		
	33. Basaltic cone or St Vincent, . . .	13. 39. 49 .	88. 46. .		
	34. San Miguel Bonelon, . . .	13. 28. .	88. 27. .		
	35. Conchagua, . . .	13. 20. .	87. 50. 30 .		3,000
	36. Coniguina or Cosiguina, . . .	13. 00. 30 .	87. 37. 30 .	1835	1,000
	37. Telpique or Hisapan, . . .	12. 55. .	87. 15. .		
XVI. Guatemala,	38. Viejo, . . .	12. 30. .	86. 53. .		9,000
	39. Viejo, . . .	12. 30. .	86. 53. .		
	40. Amoseo, . . .	12. 27. .	86. 46. .		
	41. Monsotto or V. de Leon, . . .	12. 27. .	86. 46. .		
	42. Masaya, . . .	11. 58. .	86. 16. .		
	43. Momotombo, . . .	11. 52. .	86. 34. .		
	44. V. of the Cinotepe in the Lake Nicaragua, . . .	11. 50. .	85. 45. .		
	45. Orosses or Pompon, . . .	11. 39. .	85. 40. .		9,370
	46. Rivcon de la Vieja or Zapatosa, . . .	11. 18. .	85. 30. .		
	47. Miraflores, . . .	11. 18. .	85. 30. .		
	48. Tenorio, . . .	11. 11. 30 .	84. 34. 30 .		
	49. Chiriqui or Cerro Pelon, . . .	8. 58. .	82. 36. .		
	50. Aingober, . . .	11. 11. 30 .	84. 37. .		
	51. Lava, . . .	11. 11. .	84. 37. .		9,848
	52. Esc

5. THE PHENOMENA OF VOLCANOES.

As earthquakes are often accompanied by eruptions of water and watery vapours, so we recognise in the small mud volcanoes, which are accompanied by the eruption of flames, a transition to the proper volcanoes or burning mountains. These latter, forming a permanent, or at least a frequently renewed communication between the fluid interior of the earth and the atmosphere which surrounds its outer crust, are to be considered as safety-valves for the country in their vicinity; for observation shows that the most destructive earthquakes occur at a distance from active volcanoes, as in Venezuela, Portugal, Greece, and Calabria. In a proper volcano the reaction of the interior upon the surface continues for a very long period of time; it may, as was once the case with Vesuvius, remain uninterrupted for centuries, and then present itself anew with increased activity. The degree of this activity, and especially the frequency of eruptions, appear to stand in such relation to the height of a volcano, that the latter are much more frequent when the cones are of comparatively low elevation. Thus, for example, while the low volcano of Stromboli, in the Lipari Islands (2,957 feet) has continued in a state of constant activity from the earliest ages, serving the purpose of a light-house to the navigators of the Tyrrhenic Sea, the gigantic volcanoes of Cotopaxi (18,880 feet) and Tunguragua (16,579 feet) in the Andes of Quito, have only been active once in a hundred years. If the origin of these volcanoes is at an equal depth below the surface, it must require greater power to throw the molten masses to an elevation, in the one case, six or eight times greater than in the other; for this reason the effusion of lava is much less frequent from elevated cones, and among the higher volcanoes of the Quito range, Antisana is perhaps the only one which has emitted lava streams.

These *Lava Streams* break out in irregular intermitting springs of molten earthy matter, preceded by jets of aqueous vapour, acids, and mud. The openings from which all these substances are poured forth are called *craters*, the size and form of which are totally independent of the dimensions of the volcanic mountain.

Volcanic Eruptions are generally preceded by subterranean sounds, and the other phenomena usually attendant on earthquakes; these are succeeded by dense columns of smoke impregnated with a great variety of gaseous substances, which, according to the state of the atmosphere, assume different forms, and are often interspersed with streams of burning sand; then follow molten masses and burning stones, which are vomited forth with fearful noise, and with such enormous force, that on one occasion a piece of rock, measuring three hundred cubic feet, was thrown from the crater of Cotopaxi to a distance of more than eight miles. While these substances are thus expelled from the crater,[1] and indeed, even before the eruption commences, the vibrations of the soil usually cease, and the stream of lava, escaping from the lower edge of the crater, emitting a thick streak of greyish smoke, flows down the mountain, sometimes with great rapidity, but more frequently as a slow majestic fiery current.[2]

The eruption of lava, however, is not the last of the phenomena which usually follow each other in regular succession; for, after it has ceased to flow, the activity of the vent continues uninterrupted. The appearance of volcanic ashes is always the sign of the termination of a great eruption; the fine light lava dust rises in such quantities, that for hours, and even days together, large tracts of country are enveloped in midnight darkness,[3] while the soil is covered with it to a depth of five or six feet; in the case of Herculaneum, indeed, the lava dust, driven by the wind, accumulated to a depth of from seventy to one-hundred and twelve feet.

Volcanoes which raise their summits far above the limits of the snow line present many peculiar appearances; a sudden melting of the snow indicates the approach of an eruption, even before smoke is visible, and this rapid thawing of the accumulated snows occasions destructive floods and rapid torrents, in which heaps of smoking ashes are floated along on thick blocks of ice.

II. GEOGRAPHICAL DISTRIBUTION OF VOLCANIC PHENOMENA.

a. DISTRIBUTION OF EARTHQUAKES.

However formidable in appearance the eruption of a volcano may be, it is always confined to narrow limits; but the case is very different with earthquakes which, although the oscillations they produce are scarcely perceptible to the eye, often extend their ravages over thousands of miles.

In so far as yet known, earthquakes, may occur at any point of the earth's surface. No country, whatever the nature of its formations, is entirely exempt from such visitations. Granite and mica-slate are affected by them as well as mountain limestone and sandstone, and trachyte as well as amygdaloidal formations; thus in the loose alluvial soil of Holland, as in the vicinity of Vlissingen (Flushing) and Middleburg, earthquakes have occurred; even large plains and marshy territories are not exempted from the destructive effects of these phenomena, which occur with equal power in all zones and at all seasons. If we could obtain information of the daily condition of the entire surface of the globe, we should probably soon be convinced that that surface is continually agitated by concussions in some of its points, and that it is incessantly subjected to the reaction of the interior masses.

The immense area over which these concussions extend is sometimes almost incredible; of this the great earthquake of Lisbon furnishes the most remarkable example. The concussion assumed the form of an ellipse, in which the longest diameter, characterized by the destruction which was produced on its course, extended over three hundred miles. The diameter of the district of concussion, or the space over which the shock was perceptibly felt, extended to two thousand seven hundred miles; and the area of vibration, or the greatest extent over which water was observed to oscillate at the surface, extended to about four thousand miles.

I. EARTHQUAKES OF THE OLD WORLD.

In our rapid survey of the great earthquake districts represented on the map, for the materials of which we are greatly indebted to the elaborate and valuable work of F. K. A. von Hoff,[4] we shall commence with that of the MEDITERRANEAN SEA, which, uniting on the east with the district of CENTRAL ASIA, extends from the AZORES and the CANARY ISLANDS to Lake Baikal, and forms, as Humboldt remarks, probably the largest and most regular zone of volcanic action on the surface of the globe, not surpassing in extent the volcanic girdle of the Andes, in South America. From the earliest times volcanic appearances have manifested themselves on a line extending from the Caspian Sea to the AZORES; this may, therefore, be considered as the centre from which the earthquake proceeds, and as a general rule, observation on this and in all other volcanic districts, the violence and frequency of the shocks decrease with the distance from the central line; and the direction of the primitive mountain chains determines, in most cases, the course of the earthquakes, especially of such as extend from a central line in a northerly direction. Although it is not possible strictly to define the limits of earthquakes, and the boundaries which we may assign are only to be understood as approximations to this; yet it may be affirmed, that in the Mediterranean district the boundaries of the principal concussions are limited by the more or less parallel position of the Pyrenees, the Alps, Carpathian, and Caucasian Mountain chains, in reference to the central line. In the south, they extend probably to the great African Desert, to the Delta of the Nile, and the Desert of Arabia. In order to show the course and extent of the phenomena, we shall give an outline of the progress of one of the greatest and most destructive earthquakes of modern times, which occurred within the limits of the *Mediterranean district*, or which, at least, had its origin there.

Earthquake of Lisbon, 1755. This earthquake commenced on the 1st November. Suddenly a sound of subterranean thunder was heard; this was immediately succeeded by a violent shock, which demolished the greater part of the city; and in the course of six minutes sixty thousand persons perished. The movement of the earthquake was undulatory, and it is calculated that it travelled at the rate of twenty miles a minute. A space more than four times the extent of Europe, or nearly one-twelfth of the superficial area of the globe, was shaken by this earthquake, which had for the axis of its shock a line extending from Madeira, through Lisbon, to Morocco, along the west coast of Africa, to the south of Ireland. From Lisbon, the central point, the line of devastation extended northwards to Oporto, and southwards to Ayamonte, where the Guadiana falls into the Bay of Cadiz. Within this entire space, the sea, fearfully agitated by the concussion of its bed, caused the greatest destruction. At Cadiz, a wave sixty feet high rolled over the land; at Lisbon, as already remarked, the sea at first retired to an unusual level. At Kinsale, in Ireland, the sea raged into the harbour, and overflowed the market-place; and at Funchal, in Madeira, it rose to fifteen feet above the highest water-mark. The space within which this earthquake was observed to act in opposition to the direction of the Island of Madeira, is also to be in Finland, and from Scotland to Sardinia. In Scotland, the water in Loch Lomond, Loch Katrine, Loch Long, and Loch Ness, was observed to rise and fall repeatedly to an extent of two or three feet; and this movement of the surface of the water was especially observable in the Lakes of Germany, Switzerland, and France, as well as in some of those in Scandinavia. The agitation of the waves of the sea extended even to the Antilles, where the Islands of Antigua, Barbadoes, Guadeloupe, and Martinique were overflowed; and a ship forty leagues to the west of St Vincent suffered so violent a shock, that the seamen were thrown from the deck to the height of eighteen inches perpendicular; at the same time, an unusual movement was observed on the surface of Lake Ontario in North America.

No part of Europe is more frequently visited by earthquakes than Italy, and the islands in its vicinity. Pompeii and Herculaneum were destroyed by an earthquake (A.D. 63) sixteen years previous to the time when, after having been rebuilt, they were buried under the ashes and lava ejected from Mount Vesuvius. Since that time earthquakes have been frequent in Lower Italy and Sicily but up to the twelfth century they were much less frequent than in later times, especially in the eighteenth and nineteenth centuries.

The great Earthquake of Calabria, February 5, 1783.—As an illustration of phenomena, this earthquake is less remarkable for its extent than for the concentration of its operative effects; for the surface over which the shocks were felt with alarming intensity did not exceed an area of five hundred miles. Within this space nearly fifty populous towns and villages were laid waste, nearly one hundred thousand of the inhabitants perished, and the face of the country was so completely changed, that many disputes afterwards arose as to whom the property should belong, which had so far shifted its position. The convulsions extended over Calabria ultra, and along the granitic range of the Apennines from north to south, but were not perceived to the eastward of the Gulf of Squillace. The centre of this earthquake was the town of Oppido in Calabria ultra. Hamilton says, that a circle drawn round this with a radius of twenty-two geographical miles, would include that district which had suffered most severely from the shock; the concussion was felt northwards of Oppido to Cotrone, a distance of seventy-two miles, and on the west it extended over the Lipari Islands to Patti in Sicily. The limits of this earthquake, as well as the countries in the environs of Etna and Vesuvius, which are almost incessantly convulsed by earthquakes, are delineated on the small special map of the volcanic districts of Lower Italy.

The district of the earthquake which visited *the south-eastern part of Europe on the 22d January* 1838 has far to the eastward of the central line we have been describing. The shock was observed in the vicinity of Vienna and Constantinople, as well as in the southern provinces of Russia, and was very destructive in the countries of the *Lower* Danube, at Bukarest, &c.

Besides these special earthquake districts, the other parts of Europe belonging to the *Mediterranean district*, especially Greece and Turkey, have been visited by frequent and very violent concussions. This volcanic region extends over Asia Minor, Syria, and Palestine, to the Euphrates on the one hand and the Caucasian Mountains, where the country in the vicinity of Tiflis has suffered severely from shocks of earthquakes, both in earlier and later times. Persia and the countries about the Caspian Sea, form the connecting link between the Mediterranean district and the district of Central Asia in one direction, and the south Asiatic district in another. The countries of Asia have suffered from the effects of earthquakes as great changes of surface as those of Europe, or perhaps even greater, when we take into consideration the earthquake of Cutch, which, in 1819, caused such alterations, that the bed of the eastern branch of the Indus, previously only one foot deep, suddenly attained a depth of twenty feet; or the great earthquake in Syria, 30th May 526, which was most severely felt at Antioch, and during which, it is said that two hundred and fifty thousand lives were lost; or that which devastated the same country in 1837, which extended over a space of five hundred miles in length by ninety in breadth, and by which more than six thousand persons perished.

In the DISTRICT OF CENTRAL ASIA the course of linear concussion follows, in general, the direction of the great mountain chains. On the range of Thianchan the concussions extend, on both sides, from Hami and Turfan over Aksu and Bokhara to the great depression of Turkestan. To the northward of the Thianchan, we must consider the eastern termination of the mountain system of the Altai, the plutonic fissure of Lake Baikal, and the warm springs of the Orkhon River, as the central point of that volcanic activity which, among others, caused the destruction of Karakhorum at the end of the thirteenth century. From this point the concussions spread from east to west, and, in later times especially, on the northern declivity of the Sagsai Mountains to the west end of the Kolywan Altai. They were felt in the mines of Schlangenberg as well as in Barnaul. Farther south they were observed between Lake Balkash and the Dsaisang Lake. In the great depression of Turkestan, the reactions of the Himalaya unite with those of Thianchan, Kuenlun, and Bolor, and, what is very remarkable, concussions sometimes extend right across these lofty snow-clad mountains. Sir Alexander Burnes has shown that the earthquake which he experienced at Lahore, on the 22d January 1832, passed through the chain of Hindu-kho, in a direction from south-south-east to north-north-west, destroying the villages at Badakchan and those of the Upper Oxus, while it extended still farther towards Bokhara and Kokand.[5] The Ouraian Mountains have long been considered exempt from subterranean commotions, but recently (1836–37), shocks have been felt in the southern districts, at Slatoust, Kychtimsk, and Turdojak near Miask. Whether these were produced by a continuation of the undulating motions which frequently extend through the line of the Caspian Sea to the Caucasus, is probably even to Moscow, by no means improbable.

The next in order is the EARTHQUAKE DISTRICT OF ICELAND, the boundaries of which it is more difficult to determine—probably it includes the whole of Great Britain, and even the northern portions of France, Denmark, and Scandinavia, and extends to Greenland on the north and west. But though, for convenience of arrangement, it may be considered as forming a district by itself, it must not be regarded as unconnected with the others by which it is surrounded.[6] As an instance of the connection subsisting between this and the Mediterranean district, it may be sufficient to notice the remarkable coincidence, as to time, in the great eruption of Skaptar Jokul of 1783 with that of the earthquake of Calabria in the same year.

In the remaining part of the Old World shocks of earthquakes have been observed in almost every explored region, but they occur chiefly, as might have been expected, in the vicinity of the volcanic girdle which surrounds it on the south-west. The activity of the volcanic series of the Sunda Islands has recently been manifested by the occurrence of an earthquake at Assun. One of the most frightful phenomena connected with this series was the *eruption of Tumboro*, in the Island of Sumbawa, in 1815, the concussions of which were felt in the Island of Sumatra and in the Moluccas.

As *Africa* possesses no volcanic vents (Ruuggear having shown that the supposed volcano of Koldaghi in Kordofan does not exist), so, with the exception of a part of Barbary on the north, and the regions of the Red Sea on the east, earthquakes are almost unknown in this vast continent. At the sources of the River Gambia it is reported that there are many traces of volcanic action, and that shocks of earthquakes are of frequent occurrence. In the years 1809 and 1811, slight shocks were experienced at the Cape of Good Hope.

II. EARTHQUAKES OF THE NEW WORLD.

The earthquakes of the New World are, both as regards extent and frequency, equal to those of the Old World; they occur chiefly along the coasts on the western side of the chain of the Andes, and on the northern declivity of the Mountains of Venezuela. Very few earthquakes are known to have occurred in the interior of the chain of the Andes; and this circumstance confirms the fact already mentioned, that earthquakes do not occur generally in the vicinity of active volcanoes, but rather at a distance from them, as exemplified in the very frequent shocks experienced in the vicinity of Lima. Surveying the map from south to north, we find, first, the region of the great and recent *earthquake of Chile* or *Concepcion, 20th February* 1835. This earthquake was everywhere felt between the Island of Chiloe on the south, and Copiapo on the north, and from the Island of Juan Fernandez on the west, to Mendoza on the east of the Andes. Almost all the towns and villages situated between latitude 33° and 38° south were destroyed; and while Juan Fernandez suffered from its effects, and a shock was felt in the sea in its vicinity, the city of Valparaiso, situated in nearly the same latitude, was left untouched. During the progress of this earthquake, or immediately after its occurrence, the volcanoes opposite the Island of Chiloe, viz., Osorno, Minchinmadom, Corcobado, and Yanteles, as well as several peaks in the interior of the Chile range, were in a state of the greatest commotion.

The great *earthquake of Caracas, 26th March* 1812, the concussions of which, like that of Lisbon, formed an ellipse, extended in a direction east-north-east to west-south-west, from Caracas and Guayra to the high mountains of Merida, where it appears to have been the most violent, although it was felt from near Bogota in the west to the Gulf of Paria in the east—forming part of the district which, as A. von Humboldt has so clearly demonstrated, was almost simultaneously shaken by convulsions from 1811 to 1813. The principal phenomena occurred in the following chronological order:—

January 30, 1811, an eruption of the Island Sabrina, near the Azores, which increased in size to the 15th June of the same year.

May, 1811, commencement of the earthquakes on the Island of St Vincent, which continued till May, 1812.

December 16, 1811, commencement of the concussions in the valleys of the Mississippi and Ohio, which continued till 1813.

December, 1811, an earthquake in Caracas.

March 26, 1812, the great earthquake of Caracas, which continued till 1813.

April 30, 1812, eruption of the volcano of St Vincent; and on the same day, subterranean sounds heard in Caracas, and on the banks of the Rio Apure.

Another great phenomenon of tropical America was the *eruption of Cosiguina* and the *synchronous earthquake of New Granada* in the beginning of 1835. The eruption of Cosiguina, from which, as already observed, the ashes were carried to such an amazing distance, occurred on the 20th January, and a few weeks afterwards, almost the whole of New Granada was violently convulsed; the subterranean thunder was heard simultaneously in Popayan, Bogota, Santa Martha, Caracas, Haiti, Jamaica, Curaçon, and in Lake Nicaragua. We shall close these hasty remarks with a reference to the

Earthquake of Guadeloupe, 8th February 1842,[7] in which Point à Pitre, Mule, and Joinville were destroyed, and which extended in a direction north-west to south-east, from Charlestown in South Carolina to the Islands of Antigua, Guadeloupe, Deshaerade, Marieghalante, Dominica, St Lucie, and Barbadoes, over the city of Cayenne, and the quartier Kan in French Guayana to the Island of Marajo at the mouth of the river Muranon or Amazon.

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[1] When fluidness are formed in a volcanic mountain, in consequence of the earthquake by which the eruption is preceded, the boiling lava from the interior of the earth is introduced into them more or less rapidly, and their pressure continues to operate for themselves a passage by which they flow laterally down the sides of the mountain.—*Elie de Beaumont, Recherches sur les Révolutions du Globe.*

[2] Spallanzani mentions volcanian lava of thirty feet, eruptions from Mount Etna, only ten were projected from the crater itself; and Dolomieu says that nine-tenths of all its eruptions were from the sides of the mountain.

[3] The velocity with which lava streams move is very various, and depends not only on the inclination of the soil, but also on the quantity and viscosity of the matter; one thousand feet per hour is reckoned a great rate of velocity, as Borg's stream is ten and the Cameinian Mountains, where the country in the vicinity of Tiflis has suffered severely from shocks of earthquakes, both in earlier and later times. Persia and the countries about the Caspian

[4] Geschichte der durch Ueberlieferung nachgewiesenen natürlichen Veränderungen der Erdoberfläche.

[5] A. von Humboldt, Central Asien, b. i., s. 426.

[6] F. K. A. von Hoff, Geschichte der natürlichen Veränderungen der Erdoberfläche, ii., p. 403.

[7] Edinburgh Cabinet Library, Ireland, p. 38, *et seq.*

[8] Neues Jahrbuch der Mineralogie und Petrefaktenkunde, 1840, Heft 5.

b. GEOGRAPHICAL DISTRIBUTION OF VOLCANOES.

On examining the accompanying map, it will be found that volcanoes are distributed over every part of the globe—that they are found in all latitudes, under every zone, entirely independent of climatic differences. Organic nature gives to each region of the earth the peculiar physiognomy by which it is characterized, but it is very different with inorganic nature, in those places where the solid crust of the earth is devoid of vegetation. In the latter we everywhere see the same laws of formation proclaiming themselves—the same kinds of rocks attracting or repelling each other in groups, are found in both hemispheres, from the equator to the poles; and it is especially in the phenomena of volcanoes that we are struck with this general identity of form and structure. When the European navigator, far from his native country, finds himself under skies where strange stars have replaced the constellations to which he is accustomed, and he is surrounded by the forms of an exotic flora, he still recognises forms which recall to him the dome-shaped summits of the mountains of Auvergne, the craters of elevation of the Canaries, and the eruptive fissures of Iceland.

One great fact in the distribution of volcanoes is, that by far the greatest number are found on islands or on sea-coasts; this and the occasional occurrence of submarine eruptions, early led to the opinion that volcanic action is dependent on vicinity to the sea. But the existence, in the New World, of the three volcanoses of Jorullo, Popocatepetl, and Fraguas, situated respectively at eighty, one hundred and thirty-two, and one hundred and fifty-six geographical miles from the shores of the ocean; and in Central Asia the volcanoes of Thianchan, or the Celestial Mountains, situated at about fifteen hundred miles from the nearest sea, warrant the conclusion that volcanic action does not depend on the vicinity of the sea, nor on the introduction of water into the interior regions. If coast lands appear to offer a position favourable to eruptions, it seems to be because they form the sides of profound basins occupied by the sea, which, covered with water, and situated many thousand feet below the interior of continents, present comparatively little resistance to subterranean forces.

Independent of the influence of climate in their geographical distribution, volcanoes have been ranged in two classes essentially different—the *central volcanoes*, and the *volcanic chains* or *linear volcanoes*;[1] according as they form the centre of a group of eruptions regularly disposed in every direction, or compose a connected line in which they are ranged at short distances in the same direction, like vents upon an extensive fissure. The Peak of Teneriffe is an example of a central volcano; it is the centre of a group to which the volcanic isles of Palma and Lanzerots belong; whilst the chain of the Andes, that immense natural rampart, extending from Southern Chile to the north-west coast of America, sometimes as a single range, and sometimes divided into two or three parallel branches, united at intervals by narrow transversal articulations, presents, on a grand scale, an example of a volcanic chain, or series of linear volcanoes situated on a continent.

Exact inquiries into the distribution and arrangement of present and formerly existing volcanic vents are of the greatest importance to a knowledge of the physical properties of the globe, since the existence of numerous islands, and the formation of entire continents, are clearly to be traced to volcanic action. In order to present these different systems in one general view, we have prepared the foregoing table, which exhibits the relative position of each volcano, with the system to which it belongs, distinguishing those which are active from those which are extinct, the date of last eruption, and the elevation above the mean level of the sea. It is compiled chiefly from the facts collected by Berghaus,[2] with additions from the researches of Fitz Roy and Darwin in the Pacific Ocean and South America, and those of Salomon Müller in Java—the discoveries of Ross, Wrangell, &c.

It is extremely difficult to form even an approximative estimate of the number of active volcanoes existing on the face of the globe at any certain period of time; for while one traveller considers some of them as extinct, another affirms that they are in a state of activity; many observers, not accustomed to such phenomena, frequently mistake solfataras and hot springs for volcanoes, and we are obliged to trust to vague and often very unsatisfactory reports for the fact of their existence in remote and unexplored regions. We have been at great pains to render the table as complete as in these circumstances it was possible to make it, by collecting from every accredited source all existing observations, and distinguishing by marks of interrogation those which are more or less doubtful. The number of active volcanoes thus ascertained is two hundred and seventy, of which by far the greater part, namely, about one hundred and ninety, are found on the islands or around the shores of the Pacific Ocean.

THE VOLCANIC PHENOMENA OF CENTRAL ASIA.—In the following notice of this extensive and little known territory, we shall endeavour to present an outline of the results of the elaborate researches of A. von Humboldt, who, in his "Asie Centrale,"[3] has given a complete picture of those phenomena from obscure and inaccessible Eastern authorities. The mountain system of Thianchan, or the Celestial Mountains, forms the central line of volcanic activity; nearly in the middle of this great range, and on its northern declivity rises the volcano of Pe-shan (white mountain), called Ho-chan and Aghie by the Chinese, and Echilkhash by the Turks. Farther to the east, at a distance of six hundred and seventy miles on the southern declivity, between Turfan and Pidjan, lies the volcano of Ho-tcheou (burning mountain). Both of these are isolated cones, and the only proper volcanoes of Central Asia, which are ascertained to be in a state of activity; near the same range of mountains, and in an intermediate position, there occurs only the *solfatara* of *Ouroumtsi*.

Farther northwards, in the basin which separates the Thianchan from the chain of the Altai on the one side, and from the much less elevated territory which extends to the chain of the Ural and the Caspian Sea on the other, are found the following points which form an evident connection between the interior of the earth and the atmosphere, and which appear to be dependent on the activity of the central line of Thianchan. At the distance of fifty miles north-north-west from the volcano of Pe-shan, we find the hot springs of *Arashan*,[4] and at about seventy miles farther towards the north-north-west, south of the river Ili, rises the Mount *Khobuk* on the declivity of which sal-ammoniac is gathered in the fissures of the rocks. To the northward of Lake Alaköu-kul,[5] and in a line nearly parallel with the Thianchan, lies the mountain chain of Turfangutai which separates the basin of the above-named lake from that of Lake Dusisang. At the eastern extremity of this range, is situated *Mount Sawru* which, according to Sievers, is volcanic, and which the Kirghiz assert emits smoke, and even flames; and produces a great quantity of sal-ammoniac and sulphur. About one hundred and fifty miles to the eastward of this, is the hill of *Khobuk* in the middle of a plain, on the small river of the same name, which flows into Lake Darlai. Still connected with the system of the Altai, and south from Bielouka, its culminating point, there are recognised traces of subterranean activity in the spring of *Rachmanowka*, an eastern tributary of the Bouroul which flows into the Upper Bukhtarma, the temperature of which is 104° higher than the mean temperature of the atmosphere.

Besides these great and somewhat connected volcanic districts, there are still two isolated points which show traces of volcanic activity; the one is Strahlenberg's supposed great Siberian Volcano, situated in north latitude 64° 30,' longitude 106° 20' east, between the sources of the Olenek and Vilui Rivers. The exaggerated accounts of this volcano having emitted flames, seems to have arisen from the appearance of the *fumaroles* (suffocating vapours, from which ammoniac is disengaged). The others are, the *field of fire*, a district near Bakou, on the western shores of the Caspian Sea, which continually emits inflammable gas; the mud volcanoes (*salsen*), or springs of naphtha, petroleum and mud in the same vicinity; and the naphtha springs on the Island of *Tcheleken* in the Caspian Sea.

The *active volcanic vents of China* appear not to consist of proper volcanoes, at least it is not ascertained that any of them have ejected ashes or lava streams; but the agency of volcanic action is evinced in the numerous *Ho-ahene* or fire hills, and *Ho-tsings*, fire springs or wells of fire. The latter are artificial apertures sunk in the solid rock, to a depth varying from fifteen hundred to three thousand feet, with a breadth of five or six inches; the water procured from these wells contains a great portion of salt and nitre. On applying a lighted torch to some of these, whence there is no flow of water, fire issues forth with great violence and a noise like thunder, bursting into a flame twenty or thirty feet in height. The gas has a strong bituminous smell, and burns with a bluish flame, yielding a great quantity of dense black smoke. Confined in bamboo tubes, this gas is employed in the evaporation of salt-water from the neighbouring springs.[6]

d. NOTES ON THE RAISING AND SINKING OF CONTINENTS.

The phenomenon of the gradual and imperceptible change of the relative level of land and sea, in countries situated at a distance from active volcanoes, and in which violent earthquakes are not known to have occurred within the historical era, is exemplified on the largest scale in Scandinavia.

1. *Raising.*—Through the whole of Norway, from Cape Lindesnäs in the south, to the extremity of the North Cape, the line which the ancient sea-coast attained previous to historical times, is indicated by deposits of shells identical with those of the existing sea, which, according to the very careful measurements of Bravais, are found at a height of six hundred feet above the present mean level of the ocean.[7] On the Swedish coast, the maximum of upheaving power appears to lie in Northern Lapland, to the north of the Gulf of Bothnia, and the level evidently diminishes gradually in proceeding southwards to Sölvisborg; and here, on the parallel of 56° 3' north, there is unquestionably a line crossing Sweden from east to west, along which the ground is perfectly stable, and has not changed its level for many centuries. To the south of this stationary line, however, or throughout the province of Scania (part of Cristianstad and Malmoehus), it is now clearly ascertained that the land is undergoing that gradual depression, the existence of which Mr Lyell first announced to the British public, and in proof of which Professor Nillson, who has devoted so much attention to this phenomenon, shows, among many other examples, that the village of Stafsten in Scania is now three hundred and eighty feet nearer the Baltic than it was in the time of Linnæus, by whom it was measured, eighty-seven years before.[8] There are no sufficient data for estimating exactly the area subject to this upheaving movement in Norway, but it appears to extend from Götenburg to the North Cape, a space of nearly one thousand miles, over which the rate of elevation increases as we proceed northwards. Since trustworthy observations do not extend beyond a century and a half from the present time, it cannot be determined whether the rate of upheaving force is uniform during very long periods. As to the present amount of elevation, Lessing,[9] from observations made at forty-six different points of the coast, extending along the east side of Sweden from Neder Kalix (latitude 55° 40' north), and on the west side from Koön in Babus Län (latitude 57° 43' north) to the above mentioned line at Sölvisberg in the south, estimates it at nearly four feet in a century; while A. von Humboldt[10] reckons that a period of eight thousand years must have been necessary to raise the coast three hundred and fifty feet.

Forchhammer[11] has shown that there is an upheaval of the coasts of Denmark, in the Sound as well as on the Island of Saltholm, opposite Copenhagen, and that the Island of Bornholm is rising at the rate of one foot in a century. Trevelyan also affirms that there is a process of upheaving apparent in Jütland, near Fredericksbaven, or Flatstrand, not far from the Skagen. On the Prussian shores of the Baltic, Berghaus[12] calculates, from a comparison of the state of the sea at different places, that the coast at Memel has, within a period of thirty years (1811–1840), been raised 1' 3" 42 Prussian, (about one foot four inches English). While, on the contrary, the coast at Pillau has in the same period sunk 1" 25 Prussian, (about one and a half inch English), and that at Swinemünde 1" 10 Prussian, (about one and one-eighth inch English.) In our own island, Prestwick has shown that a process of upheaving is in operation on the coast of Banffshire, in the Moray Firth; and Trevelyan has called attention to a similar occurrence in the Channel Islands, especially at Guernsey.

2. *Sinking.*—The recent observations of Dr Pingel and Captain Graah confirm the opinion that a large portion of the coast of Greenland has been gradually sinking during the last four centuries. "Ancient buildings on low rocky islands and on the shore of the mainland, have been gradually submerged, and experience has taught the aboriginal Greenlander never to build his hut near the water's edge. The Moravian settlers have been obliged more than once to move inland the poles upon which their large boats were set, and the old poles still remain beneath the water as silent witnesses of the change."[13] The area of this submergence extends, as shown on the map, from Igalliko Fiord on the southern coast, latitude 60° 43' north, over Julianen-haab, Frederick's-haab, the Fullaartalik Islands, and Godt-haab, to Nappassok, latitude 65° 20' north, and probably even to Disko Bay, near latitude 69° north.

Besides the inconsiderable depression of the Prussian coast at Pillau and Swinemünde on the Baltic, as shown by Berghaus, Forchhammer has also, with considerable certainty, shown that a part of the west coast of Denmark, especially between Römöe and the Schleswig coast, is undergoing a similar change.

[1] Leopold von Buch Deserip. des Iles Canaries, p. 544.
[2] Länder und Völkerkunde, band ii., s. 605-779.
[3] Asie Centrale, tome ii., (German edit., band i.)
[4] Arashan is the name which the Mongols give to all thermal and mineral springs.
[5] The Island Aral Tuke in Lake Alaköu-kul, has long been considered as an active volcano, and although the contradictory statements of Tartar itineraries rendered the fact doubtful, it was still involved in obscurity till, in the year 1841, the zealous Russian naturalist Sobreick ascertained, by personal examination, that the island contains not the slightest appearance of volcanic formation. During a journey to the Ala-tau in the previous year, M. Sebreick visited the lake, and not being able to procure a boat he nearly sacrificed his life in attempting to reach the island by swimming; he then announced his opinion that it was not volcanic, which was fully confirmed in the spring of 1841, when he succeeded in transporting a boat to the lake.—*Asie Centrale*, Supplement, vol. ii.
[6] A. von Humboldt's *Fragmens Asiatiques*.
[7] Kosmos, band i., p. 213.
[8] Journal of the Royal Geographical Society, 1845, part i., p. lxxi.
[9] Berghaus, Länder und Völkerkunde, band. ii., p. 276, *et seq.*
[10] Kosmos, band i., p. 215.
[11] Lond. and Edin. Phil. Mag., Sept. 1837, p. 209.
[12] 10th Lief. des Phys. Atlas, pp. 121, 122.
[13] Lyell's Principles of Geology, vol. ii., 6th edit., p. 421.

ARRANGEMENT OF THE MAP.

THE upper part of the sheet contains a Chart of the World, presenting a general view of volcanic phenomena. But as the scale is too small for the insertion of the names of separate volcanoes in densely crowded groups, such as those of Guatemala and Java, we have given below two special maps, on a scale three times larger than the general map, one of which contains the volcanic series of Quito, the Antilles, Guatemala, and Mexico; and the other that of the Sunda, Philippine, and Molucca Islands. In the intermediate space are given six special maps, all of which are projected on a uniform scale of 1/6 000,000, (about thirteen times larger than the general map), on which are delineated the details of position, extent, and geological formation of five of the most important central groups, and the linear series of the Greek Islands.

*** The explanation of the various signs and colours used to distinguish the different phenomena will be found in a note under the title of the map.

COMPARATIVE VIEWS OF REMARKABLE GEOLOGY, MAP No. 8.

GEOLOGICAL PHÆNOMENA.

A SERIES OF

DETAILED MAPS, PLANS, SECTIONS, AND VIEWS OF VOLCANIC AND OTHER INTERESTING GEOLOGICAL FORMATIONS.

INTRODUCTORY NOTE.

"It appears to me," says A. von Humboldt, "of the greatest advantage to geology to be enabled to compare the forms of mountains in the most distant parts of the globe, in the same manner as we are accustomed to compare the forms of vegetables under different climates."[1] The selections presented in the accompanying map have been made in accordance with these views of the illustrious philosopher. In the Map of the Phænomena of Volcanic Action (No. 7 of this division), we have given a general outline of the geographical distribution of volcanic forces over the globe; and the present sheet, which may be considered as an appendage to the former, presents, on an enlarged scale, detailed views of the peculiar form and extent of some of the best known volcanic and other geological formations.

Such representations, when accurately delineated, are of the utmost value in conveying precise ideas, not only of the geological structure, but also of the physical formation of the countries in which they occur; and in preparing new drawings of the different subjects, adapted to the plan of the Physical Atlas, we have anxiously endeavoured to convey the full effect, while preserving the minutest detail of the originals.

These interesting tableaux, for several of which we are indebted to the laborious researches of the most distinguished naturalists, having been selected for the purpose of affording comparative views, it would have been desirable, had this been compatible with distinctness of detail, to have constructed them all to the same scale; but as this was not possible in our limited space, we have endeavoured, by preserving an exact relative proportion between the several scales employed, to render a comparative estimate of surface extent easy and expeditious.

Thus, in the upper division of the sheet, the Map of Teneriffe is drawn to a scale of 1-600,000 (about nine miles to one inch); the middle compartment, containing South Keeling Island, Pichincha, Antisana, and the Island of Ascension, 1-200,000 (about three miles to one inch); and the lower division, containing the crater of Gedee, Graham Island, and Arthur's Seat (as well as the craters of Vesuvius and Etna on the upper compartment), 1-20,000 (about three inches to one mile). The three scales, therefore, bear to each other the proportions of 1, 10, 30.

All the subjects have a direct reference to volcanic phænomena, except South Keeling Island and Arthur's Seat; the former of which was introduced to show the contrast between the coralline and the volcanic formations; and the latter, which was surveyed expressly for this work, as affording a ready means of comparison between known and unknown objects. Thus while the low reefs of the lagoon-atolls scarcely rise above the waves of the surrounding ocean, the volcano of Pichincha towers to the height of nearly 16,000 feet, although the former occupies fully as much horizontal surface as the latter. A similar comparison shows the vast extent of the crater of Gedee as compared with the craters of Vesuvius and Etna; and the relative size of each may be realized by comparison with the outlines of the different formations of Arthur's Seat. From these general remarks we proceed to a brief description of the several objects delineated, referring for full information to the writings of the respective authors.

PHYSICAL MAP OF THE ISLAND OF TENERIFFE.

Teneriffe, the largest and most important of the Canary Islands, extending between latitude 28° and 28° 36′ north, and longitude 16° 5′ and 16° 55′ west, is about 60 miles in length, and from 5 to 30 miles in breadth. The position of the British consul's house in Santa Cruz is latitude 28° 28′ 4″ north, longitude 16° 14′ 7″ west; and the Peak of Teneriffe, or the *Pico de Teyde*, latitude 28° 16′ north, longitude 16° 38′ west.[2] In describing the chief physical features of the island, we shall follow the arrangement adopted by its illustrious explorer, referring to the original work[3] for the most ample details.

Circus of the Peak.—The Peak is surrounded by a girdle, which gives it the appearance of a fortified tower, encircled by its fosse and bastion. It indistinctly seen on ascending to the foot of the *Piton*, by the strait passage *El Portillo*. Thence the rocks appear to form a sort of semicircle, which surrounds, with remarkable regularity, the volcanic cone. This is the circus, from which point alone the prodigious elevation of the Peak can be judged of, for here it is seen in all its parts, from its most elevated ridge to the most minute particulars presented by the slopes of the cone. Streams of black obsidian descend on the flanks of the mountain, covered with white pumice, and the volcanic mouths of the *Estancia obsar, Estancia ovelo*, and *Altavista*, which appear to be points whence so many currents of obsidian have flowed, form as it were the steps of the cone, and, by dividing its height, afford a sort of scale by which to estimate the immense elevation of its summit.

Adexe is situated to the north-west of the Peak, to the south-west of the Peak, in a place where the flank of the mountain is hollowed by a deep ravine, in the middle of which flows a considerable rivulet—a rare circumstance in the island. This valley, bounded on each side by perpendicular rocks, and called *Barranco del Infierno*,[4] is a fissure opened in the interior of the mountain, which penetrates even to the circus. The crater of elevation is formed in the north, and has therefore burst out over its sides the basaltic beds which are formed on its upper parts. The immense cone of the Peak which rises in the middle of the crater, and all the substances which have been ejected from it, present in all directions no other rock; whence this volcano is essentially trachyte, like the greater number of those which have been studied with care.

Base of the Peak to the north and north-west. From the point where the perpendicular rocks forming the circus terminate, above *Adexe*, the whole flank of the mountain of the Peak is covered by volcanic lava, which sometimes such immense masses as to extend, in small black streams over a space of many leagues. The villages of Guia, Chio, and Arguajo, are built of these lava stones. The barance of *Juan Lopez* is separated into two parts by a mountain 2,453 feet high, in which is the narrow defile of *Corrizal*, excavated in the immense cape of Teno, the north-west point of the island. The wide Valley of *S. Ygo* communicates with that of El Palmar[5] in the middle of which there are two very remarkable volcanic cones, which occupy its entire breadth. The stream of lava which these cones have ejected flows towards *Buenavista*, and is composed of masses having the form of great scales, between which are numerous cavities. South of *Garachico*, between two mountains, is seen the lava stream which, in 1705, overspread this town, and filled up the best, or rather the only, port of Teneriffe. The lava flowed from several volcanic cones, elevated more than 1,063 feet above the level of the sea. Immense sterile blocks piled one upon another, like moraine upon a glacier, cover the surface of the lava. The greatest stream, and that which divided the narrow port of Garachico into two parts, advances far into the sea.

The Mountain of *Chahorra* is united to the Peak at its base, and is only separated from it in its higher regions. All the currents of lava have flowed immediately from parts of the base common to both; and of all the streams which descend to level, there is hardly one whose origin is situated below the base of the Peak: they have thus in great part flowed from a height of more than 9,592 feet, and are spread over a space of a league and a half. The appearance of these lava streams must necessarily have preceded all vegetation; for, during the succeeding improbable ages, which have produced these masses, sufficient to cover a space of more than a mile square, the island could have continued habitable.

The Peak is properly a mountain which rises upon another mountain. On entering the circus by the defile of Portillo, the traveller has only arrived at the foot of the lava mountain. He must pass at the parts which are pepper to it, and by which it is distinguished from the protuberances which precede it; all of which, however high, can only be considered as an exterior envelope which does not essentially belong to the Peak. From Portillo, the flanks of the cone present such a mass of pumice-stone, that the whole mountain appears at a distance as if entirely covered with snow. Currents of obsidian detach themselves on the pumice, like broad black ribbons depending from the summit. Some of these extend to the bottom of the circus; others, arrested at mid height, remain suspended on the flank of the cone; others, again, extend to so little distance that they can only be distinguished on the summit of the Peak by their black colour, which contrasts so strongly with the white surface on which they repose. This porous surface cannot sustain either trees or grass; the only bushes which can vegetate on its arid and dry soil, are *Spartium nubigenum* and *Retamat blanca*; the roots of which extend to a considerable distance on the exterior surface. A few hundred feet above the base of the Peak is the *Monte Trigo*, or mountain of wheat; so called because the pieces of pumice-stone roll upon each other along the slopes of the mountain like immense grains of corn, and because this part of the cone appears to be entirely covered with such grains.

Above Monte Trigo is *l'Estancia obsare*, a small plain, where travellers who ascend the Peak usually pass the night. This place is 8,568 feet above the level of the sea, and more than 2,150 feet above Portillo. Beyond this plain, the flank of the mountain rises rapidly along a current of obsidian: the route follows a serpentine course, and the pumice-stones are larger. For half an hour the road follows the current of obsidian to *Altavista*, where the traveller is obliged to quit the pumice-stone to mount on the obsidian itself; it is then with great pain and difficulty that one can guide himself across the sharp blocks—the fragments of which resemble those of which results from the breaking of the blades of a knife. It requires more than half-an-hour to traverse this field of glass, and it is certainly not without reason that this part of the route has received the name of the *Malpaye*.

In the middle of the field of obsidian, the blocks piled over one another have formed a deep grotto, the bottom of which is constantly covered with ice. This grotto, called *Cueva del Hielo*, is very valuable on account of the ice, of which it yields a constant supply to the localities at the foot of the mountain.

Beyond the Malpays rises the last cone, *the Piton, or sugar loaf*, which is singularly abrupt, and everywhere covered with white pumice. The height of the Piton is not more than 852 feet: but the small particles of pumice which cover its surface have so little consistency that it is ascended with great difficulty. The most elevated point of the crater is that towards the north-east, and the lowest on the south-west. From this point the crater sinks very little to its centre, the difference of level between these two points being at most 21 feet. From all sides, except some points on the west which present abrupt rocks, there is an easy descent to the interior of the crater, which is nothing more than a *solfatara*, from which sulphureous vapours are disengaged at almost all parts. Its entire circumference is at least half a league; its depth from the highest elevated point is 170 feet, but above the greater part of its sides it is not more than 106 feet. The interior does not present any trace of other small craters, nor is there any scorice. It appears, indeed, for ages to have been only a solfatara. From the rocks on the western side, a new crater is seen to open up beneath the foot of the spectator, larger than that which forms the summit of the Peak; this is the immense crater of *Chahorra*. This latter mountain was unknown to naturalists till 1803, when it was discovered by M. Cordier, who thinks, since its ætner, and the streams of lava which have issued from it, so far surpass those of the Peak, that it should be considered as the principal mountain of the volcano. The height of the *Pico de Teyde* is 12,182 feet; hence the height of the cone above the surface of the pumice-stone of Chahorra is 2,345 feet. The crater of Chahorra is of no great depth—perhaps not more than 148 feet. The most elevated point of this mountain, the southern border of the crater, which is 9,886 feet above the level of the sea, is covered with pumice. At the foot of the Mountain of Chahorra, on the west side, rise four other volcanic cones, which, on the 17th June 1798, reminded the inhabitants of Teneriffe that they dwelt at the foot of a volcano. These cones are all disposed on a line directed from the base of Chahorra towards the rocks of the circus; thus indicating the direction of the line of fracture. From the third of these cones a stream of lava reached the circus; but the wall of rock prevented its farther descent, so that the fear of the inhabitants of Guia, Chio, and Arguajo, that the lava would reach and destroy their plantations, was unfounded. The two volcanoes of Chahorra form only one immense dome of trachyte, enveloped on almost all sides, as by a mantle, with beds of basalt. The form and position of these cones suggest the idea—and this hypothesis is almost a certainty—that they have been produced by the raising of a mass urged by internal pressure to the surface, and which, in forcing for itself a passage through the middle of the crater of elevation, caused the superior mass to assume the form of a vault.

Guimar, situated on the south-east part of the island, is separated from *Orotava* by the Mountains of the *Cumbre*, from the summit of which is seen the volcano of Guimar, a great cyptive cone, 2,282 feet high, whence a stream of lava descends. This current is divided into three branches, each of which terminates with a particular opening in the flank of the mountain; but these openings have all been produced during the same eruption; and this—the only one which has occurred in this part of the country—commenced, according to Viera, on the 31st December 1704. On the 24 February the lava reached Guimar, and destroyed the church.

From the time of the conquest of the island, towards the end of the fifteenth century, there has been no eruption of Teneriffe, at least no document has been discovered mentioning such an event. This eruption was therefore the first during many centuries; which is the more remarkable, since the renewal of activity in the volcano was not limited to the country around Guimar, but immediately manifested itself also on the other side of the principal crater. The eruption which destroyed *Garachico* occurred on the 5th May 1706, by a crater which is situated so exactly opposite the volcano of Guimar, that a line joining the two would pass through the cone of the Peak, and at a little distance from the summit. The eruption which followed occurred on the 17th June 1798. Nearly a century had elapsed between the two, but this last occurred on the upper flank of the Peak. Hence it appears evident that the eruptions are connected with the great crater of the Peak, which forms the principal communication between the interior of the globe and the external atmosphere, and that they are not owing to independent volcanic sources. It results from this that, properly speaking, there is only one volcano on the island, and that is the trachytic dome which bears the name of the Pico de Teyde.

VOLCANOES OF PICHINCHA AND ANTISANA.

These important volcanoes, for the representation of which we are indebted to the surveys of A. von Humboldt, are situated on the Andes of Quito, where the chain reaches its greatest elevation, in the republic of Ecuador. The Andean chain here forms a double ridge of colossal summits, enclosing that vast basin depressed between the walls of mountains, the highest individual region of the globe, which extends from 25 to 30 miles in breadth, at an elevation of from 9,000 to 9,500 feet above the level of the sea. Pichincha is situated on the western chain, in latitude 0° 12′ south, longitude 78° 50′ 30″ west; and Antisana on the eastern ridge, in latitude 0° 29′ 45″ south, longitude 78° 24′ 30″ west. The elevation of the principal points in this part of the Andes are, Antisana, 19,1277 feet; Rucu-Pichincha, 15,922 feet; the town of Quito, 9,541 feet; the country seat of Chillo, near the plain of Carihuaysie, 8,875 feet; and that of Pintac, to the south-east of the former, 10,182 feet.

Humboldt has remarked that the greater part of the high region of Quito, as well as the neighbouring mountains, is formed of an immense volcanic dome, which, extending from north to south, embraces a space of more than 600 square miles. Cotopaxi, Tungurugua, Antisana, and Pichincha, are elevated above this vault like the different summits of the same mountain. The masses of which it is composed are nowhere seen in contact with those of the other of these volcanoes; and when the obstruction of one of the craters would lead to the belief that the volcano is extinct, it often happens that the volcanic action is exercised with undiminished intensity in the interior, and in its vicinity below as well as below the volcanoes of the highest mountains. The vault of volcanic vault, at which a new series of volcanoes commences, is separated from those of Peru by a space of 14 degrees of latitude; which space is occupied by the chain of the Andes, among the highest mountains on the surface of the globe. We know nothing of the nature and composition of the northern part of this chain, except from the observations of A. von Humboldt and his scientific companions in the voyages of M. de Helm. The little we do know, however, is sufficient to show how much its character differs from that part which is absolutely free from volcanic action."

The volcanoes were in a state of activity in the year 1599, since which time it does not appear to have made any considerable eruption[6] although Humboldt saw smoke issuing from several openings in March 1802; and it is the only one of the volcanoes of Quito on which he observed, near the summit, something analogous to a current of lava. This current was similar to obsidian. On the slope of the mountain there was also noticed pumice-stone and scoriæ, having the appearance of pitchstone."[7]

Pichincha. There are two mountains of this name—Rucu (the old), and Guagua (the young), Pichincha.[8] The first, the easternost of the three rocks which border the crater, is the only volcano on the western chain which has preserved numerous traces of its former activity. Two considerable walls, the mutual relations of which are indicated on the section, differ in height. Those on the north rise to about 295 feet, and those on the south to only 98 feet, above the level of the plain of lava (marked A on the plan). This plain is slightly upheaved at the centre, whence rises, in the form of a sugar loaf, the cone of ashes which, properly speaking, terminates the crater of Vesuvius.

The mode of formation of this plain is thus explained. The crater of Vesuvius had a depth of 426 feet, when, in the month of March 1827, the volcano gave the first indication of renewed activity. Then the volcanic subtances, accumulated in the depths of the mountain, during an absolute repose of six years, impelled by the elastic fluids, opened a vent by different crevices, which traversed the surface of the crater; and currents of lava, accumulating one upon another, successively filled up its enormous cavity. For a considerable time the volcanic mouths changed their position upon the continually torrefied surface. They formed themselves, however, constantly above a great fissure, directed from the south-west to the north-east, and which the mass of matter, incessantly deposited above it, could not obliterate. These different openings ended by all uniting, and forming, so to speak, a single centre of eruption, within the circle of which arose the actual cone of ashes, by the successive accumulation of ejected substances always disposing themselves around the same orifices. The form of the crater of the cone represented on the plan is that of a funnel of about 82 feet deep, at the lowermost part of which are seen two openings half filled, the alternate activity of which, doubtless, gives to the crater its elliptic form.

"The great mountain of Pichincha has four principal peaks: *Rucu-Pichincha*, on which M. de la Condamine was for a few minutes, but did not measure; the *obelisk* to *Lorbeth*; *Pan-Cuca*; and *Guagua Pichincha*. A fifth peak of a greenstone form, a third against which abuts the extreme called *Condampichincha*. (*Humb., Südamerik. Reisen.*, p. 48.)

[1] Vues Pittoresque des Cordillères, &c., p. 291.

[2] See the small map of the Canary Islands, in sheet No. 7 of this division.

[3] Description Physique des Iles Canaries, par Leopold de Buch.

[4] Barranco (Span.), a ravine or narrow glen. The barranco of Teneriffe seldom contain water, and are rather a sort of fissure in the flanks of the mountains than true glens.

[5] So called, because palm trees appear for the first time in this part of the island.

[6] As the elevation of these mountains is very erroneously stated in many recent works, we subjoin the original measurements, viz., Antisana, 3,353 toises; Rucu Pichincha, 2,585 toises. (*Humboldt, Vue Recue.*, p. 208.)

[7] Humboldt; Relation Historique, ii. 12.

[8] E. A. von Hoff Geschichte der Erdoberfläche, ii. 482.

[9] L. von Buch, Descr. Phys. des Iles Canaries, p. 464.

[10] Nivellement Barom., p. 52.

[11] "The great mountain of Pichincha has four principal peaks: *Rucu-Pichincha*, on which M. de la Condamine was for a few minutes, but did not measure; the *obelisk* to *Lorbeth*; *Pan-Cuca*; and *Guagua Pichincha*. A fifth peak of a greenstone form, a third against which abuts the extreme called *Condampichincha*. (*Humb., Südamerik. Reisen.*, p. 48.)

[12] Von Hoff, ii. 485.

[13] Vues illustrative de quelques Phenomenes Geologiques prises sur le Vesuve e l'Etna. Paris, 1826.

Section of Etna in the direction from West to East.

Section of Vesuvius in the direction from South to North

Scales for distances and heights

English Feet

English Miles

PLANS OF THE CRATERS OF VESUVIUS AND ETNA BY H. ABICH, 1834.

Punta del Palo 3579

Punta dell' Evone

Punta di Ottajano

Punta del Mauro

Punta dell' Angelo 3636

Punta delle Torre

Scale 1/20.000 of Nature

(Same as in Plans of Gedee, Ferdinandea, and Arthurs Seat)

English feet

COMPARATIVE VIEWS OF REMARKABLE GEOLOGICAL PHENOMENA

BY A.K. JOHNSTON, F.R.G.S.

The figures throughout indicate the feet above the level of the sea.

1. Chavo. 9924
2. Estancia de arriba de Abaxo
3. Llano de los Retamas
4. La Cinada
5. Roque Chahao
6. Boca de Tauze
7. Paso de Ouavora
8. Agua Manza 4072
9. Fuente del Brago
10. Pco Uredo

Punta de Buenavista

Punta de Teno

Pico de Teyde

Punta Rasca

Scale 1/200.000 of Nature

Geographical Miles

PHYSICAL MAP OF THE ISLAND OF TENERIFFE, BY Leopold von Buch.

SOUTHERN VIEW OF ETNA FROM M.PO NEAR CATANIA by W.S. von Waltershausen.

VIEW OF THE SUMMIT OF THE PEAK OF TENERIFFE and of the Crater of elevation which surrounds it. From the East. by Leopold von Buch.

Horsburgh I.

Direction I.

Water I.

Gooseberry I.

Ross I.

Selima, Faetleo or South East I.

Section from A to B

In the section the scale is the same for height as for distance.

CHART OF SOUTH KEELING ISLANDS surveyed by the Officers of H.M.S. Beagle

Scale 1/100.000 of Nature

Geographical Miles

Explanation of the figures on Pichincha.

1. Encapichincha	15,922	8. Rock where the boiling point	
2. Guagua pichincha	15,731	was determined	15,096
3. Pecacho de los Ladrillos	15,360	9. Plain of Iliurcocha	14,426
4. Tabla Loma	15,283	10 " " Verdecocha	13,836
5. Jupiguloo		11. Valley of Tigualla	
6. Ringa de la loma		12. La Garganta del Volcan	11,260
7. Loma gorda		13. Waterfall of Cantuna	11,050

PLAN OF THE VOLCANO OF PICHINCHA AND ANTISANA Surveyed by A. VON HUMBOLDT

Scale 1/100.000 of Nature

Geographical Miles

PICHINCHA

QUITO Pop. Columbia 9544

Cotopaxi

Tunguragua

Tumba

Cambayo

Guamgopolo

Llangas

Chillo 8515

Plain of Tiocshapambe

Cangalli

Pintac 10172

Sangolqui

Conocoto

Hallogallo

Achupallas

Jehuambo

Pansaleo

Tiocsambo

Amoingana

Quambicha

Ruminaui

El Pobregal

Cordillera de los Andes

Western Chain

Eastern Chain

Plain of Quinto

Yachuni

Stream of Lava called el Volcan de Antisana

Plain of the Pedregal

Sincholagua

Longitude W of Greenwich

CANOES OF ANTISANA

Surveyed by A. VON HUMBOLDT

Scale 1/100.000 of Nature

Geographical Miles

Cordillera de los Andes

Plain of Cuvillan

Plain of Ysacia

ANTISANA 19.137

Chasseloup

Tablacumi

Antisana

Basin of a former Lake 13.413

Cacanua

Pinsaqui

Plain of the Pedregal

Stream of Lava called el Volcan de Antisana

Ex or Yanayalpa or la Lanja

S. Antoine

Louis gorda

Embocadura

Note

The figures indicate height in feet, above the level of the sea.

The snow line on Antisana is coloured Blue.

CHART OF ASCENSION ISLAND Surveyed by Lieutenant Campbell R.N.

View of Ascension Island from the Mountain Road.

Scale of Chart same as in Plan of Pichincha & Antisana and S. Keeling Is.

Section from A to B on Plan

Section from C to D on Plan

Position of Royal Observatory

Latitude 55° 57' 35" N.

Longitude 3° 10' 0" W.

Colours: Sandstone & Shale; Trap; Basalt; Greenstone; Porphyry; Amygdaloid

In the Sections the scales are the same for height as for distance.

PLAN OF THE CRATER of GEDEE IN THE ISLAND OF JAVA Trigonometrically Surveyed BY Dr Salomon Müller 1836.

Scale 1/10.000 of Nature

English feet

Kandang Badak 7780

Goenoeng Besaoeng 9022

Solfatara

Goenoeng Sorenda

Goenoeng Koenia koering

Shrubs and small trees

Mass above 9000

Forests, Lempoyangs

Precipitous rocks with shrubs of Compositious Ferns

Goenoeng Gedee

Sketch of the appearance of Graham Isld. 18 July. 1831.

A The Crater, Boiling Water B The Landing place C 107 feet high D Ebullition (outside of Island)

PLAN OF GRAHAM ISLAND, by Capt. C.H. Seymour, 1831.

Scale 1/1000 of Nature

COMPARATIVE VIEW OF THE ELEVATION OF THE PRINCIPAL ACTIVE VOLCANOES ON THE GLOBE.

NEW WORLD

OLD WORLD

PLAN OF ARTHURS SEAT, from an ORIGINAL SURVEY.

Scale 1/6000 of Nature

EDINBURGH

Calton Hill

Arthurs Seat

Salisbury Crags

Holyrood House

Canongate

Drawn by A. Petermann, F.R.G.S.

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

85131

seat, was an upheaval in the form of a dike (*e e* on the plan), which was produced at the base of the cone, and which tended to unite with the edge of the great crater. This has been designated the promontory of the cone of ashes. At the commencement of its formation, this dike sank insensibly, and was confounded with the plateau; but immediately, almost at the western base, it was traversed by a great fissure, which opened in the direction north-east to south-west, and, by an angular turn, continued in the direction of north-west. Then all the eastern part was upheaved about 24 feet above the plateau, and presented, in the part opposite the other side of the cleft, a sort of steep bench, as if cut with the pick-axe, and the fracture of which allowed the beds of lava, elevated at the same time on that part of the ground, to be very easily distinguished. Shortly after, new liquid substances sought to open a passage for themselves in this place, and, by a very peculiar effect of this phenomenon, the opposite side of the cleft which remained stationary, gave birth to a series of little cones of eruption, which followed the contours of the bottom of the cleft, to their junction with the sides of the great crater. These little cones were formed in two distinct groups. The first group (*f*) followed the whole north-east side of the cleft; and when its activity was diminished, the second (*e*) appeared on the north-west side. The greater part of the lava escaped from the base of small cones, by openings (*d*) in the scorified and indurated surface, in a manner similar to that of water overflowing the gaps in the ice which covers a river. The letter (*d*) indicates an upheaval of the soil, in the form of an elliptic dome, traversed by considerable fissures, all placed against the western part of the base of the cone of ashes. The points (*h*) indicate the sites of powerful *fumaroles*, or smoking fissures, the influence of which tends continually to the destruction of the elevated wall of the Punta del Palo.

PLAN OF THE CRATER OF ETNA.

This plan, constructed in the same manner as the preceding, represents, in as far as the natural difficulties of the ground would permit, the crater of Etna in the state in which it was left by the eruption of November 1832. Four months after this event, in February 1833, the volcano being in a state of the most absolute repose, I measured on the summit of the mountain a number of hollows of various form and depth. These hollows, following a right line direction, began to show themselves at the Torre del Filosofo, which, as well as the ground on which it is built, is sunk to the extent of nearly 15 feet. They became the beds of lava, surrounding the cone; then rising to the summit, lose themselves in the interior of the crater, on the side opposite Bronte. The most extensive of the hollows, placed on this line, forms an oval opening (*a*) on the crest of the south-east edge of the crater. This opening, with a diameter of more than 320 feet at its orifice, and of an immeasurable depth, presents vertical walls which, however, which admit of easily distinguishing at their surface the section of stratified substances, following two lines of declivity, inclined in two opposite directions—the one towards the centre of the crater, and the other towards the exterior base of the cone. The crater itself, in consequence of the above occurrences mentioned, which have destroyed its north-eastern side, is giving to the cone an oblique and truncated form, presents a most complete appearance of disorder and destruction.

b indicates one of the craterriform openings of nearly 53 feet deep, which have been produced during the last eruption upon the surface of the crater, and which served as a passage to the vapours and the incandescent scoriæ.

c great conical masses of scoria, the evident residue of old cones of eruption, which have also been formed by the ejection of scoriæ.

d the place where, at the commencement of the eruption of 1832, the boiling lava in the central chimney opened a passage for itself, by which it commenced to flow over the declivity of the cone, until the flank of the volcano opened 7,460 feet lower, near Bronte.

e represents a breach at the lowest part of the crater, which forms, so to speak, a natural entrance into its interior.

f on this point there arises a mass of lava, composed of spheroidos.

g indicates the sunken part of the sides of the crater.

h highest ridge of the crater which remains entire.

i i shafts communicating with the interior of the volcano.

k indicates openings similar to those of mine-pits, in connection with the eruption of 1792. They occupy the bottom of a wide crevice.

l masses of scoriæ ejected by the lateral eruptions of 1787.

m pit-like openings, which extend to Torre del Filosofo.

SECTIONS OF VESUVIUS AND ETNA.

The sections of the burning volcanoes of Italy, were traced according to the researches of M. Abich, and the barometrical measurements of M. Hoffman in 1832. In both the sections the scales are the same for height as for distance.

Fig. 1. Section of Etna from west to east.—The contours of Etna, figured in this section, are exactly the same, in regard to aspect, as those which are observed on the route from Naples to Messina, in the vicinity of the Lipari Islands.

Etna does not present a regular and symmetrical form on all sides. Its central mass rises in the form of an elliptical cone, upon a slightly upheaved surface, above a base of 92,721 feet, in the direction from east to west.

On the east, the soil descends towards the sea, under a highly inclined angle, whilst on the west is flattens, forming a very gentle slope to the calcareous and arenaceous rocks of the secondary formation which skirt the circumference of the mountain, at an absolute height of about 2,131 feet. The central mass, which forms Etna properly speaking, is truncated by an almost plain surface. The cone which terminates the crater does not occupy the centre of the mountain; it is to the north-east, where is the most abrupt slope of this mass. The Val di Bove, that vast elliptical depression on the eastern flank of Etna, is represented in this section in its entire length. The dotted line shows the direction of the slope of the mountain, and the position of the interior walls which circumscribe the Val di Bove. Zaffarana is a little village situated at the entrance of the valley.

Portella and Salto di Giumento are the limiting points of the principal divisions of the valley in the form of terraces.

The hatched lines, which run parallel with the dotted line, indicate the inclination of the layers of rock of which the interior of the mountain is composed.

Fig. 2. Section of Vesuvius.—This section is drawn in the form of a line, which starts on the north of Somma, a village at the foot of La Somma, and terminates on the south at Torre d'Annunziata, on the sea-shore. It is best calculated to give an exact idea of the relative situation of the two masses which compose the group of Vesuvius.

The points of Fontana dell'Olivella and Cancarossi, served as poles to determine more accurately the angle of inclination of the lower part of La Somma. Punta di Nasone is the culminating point of the narrow and somewhat denticulated crest of La Somma. Atrio del Cavallo is the space between the re-curvated escarpements of La Somma, and the base of the cone of Vesuvius. Punta del Palo is the most elevated point of the edge of the crater, and, consequently, of the whole group. Bocche Nuove indicates the position of the craterriform mouths which were formed during the great lateral eruption which destroyed Torre del Greco. Farther southward is the hill of Camaldoli, composed of fragmentary substances.

CHART OF SOUTH KEELING ISLAND.

According to the interesting researches of Darwin,[9] this is one of the many singular structures reared by madrepores on the summits of submarine mountains, with which the Pacific and Indian Oceans are studded. It belongs to the class of annular lagoon islands, of which one in structure is in most respects characteristic; it is situated in the Indian Ocean, in latitude 12° 5′ south, longitude 96° 55′ east, and its greatest width is nine miles and a-half.

The Keeling atoll, like other coral formations, has been entirely formed by the growth of *organic* beings and the accumulation of their detritus. "Every one," says Mr. Darwin, "must be struck with astonishment, when he first beholds one of these vast rings of coral-rock, often many leagues in diameter, here and there surmounted by a low verdant island with dazzling white shores, bathed on the outside by the foaming breakers of the ocean, and on the inside surrounding a calm expanse of water, which, from reflection, is of a bright but pale green colour. The naturalist will feel this astonishment more deeply after having examined the soft and almost gelatinous bodies of these apparently insignificant creatures, and when he knows that the solid reef increases only on the outer edge, which day and night is bathed by the surf, and not on the inside, where the water is tranquil." The reef which the atoll is described as a ring encircling the lagoon on all sides except at the northern end, where there are two open spaces, through one of which ships can enter.

This reef varies in its width from 200 to 2,000 yards; its surface is level, or very slightly inclined towards the lagoon, and at high-tide the sea breaks entirely over it. The most frequent coral in the hollows on the reef is *Pocillopora verrucosa*, which grows in short sinuous plates, or branches, and whose surface is of a beautiful delicate pale-red; a madrepore, closely allied or identical with *Millepora alcicornis* is also common. As soon as an islet is formed, and the waves are prevented from breaking entirely over the reef, the channels and hollows in it become filled up with cemented fragments, and its surface is converted into a hard smooth floor, like an artificial one of frestone. This flat surface varies in width from 100 to 200 or even 300 yards, and is strewed with a few large fragments of coral torn up during gales; it is uncovered only at low-water. "Nothing can be more singular than the appearance at low tide of this 'flat' of naked stone, especially where it is externally bounded by the smooth convex mound of Nullipore, appearing like a brook-water built to resist the waves, which are constantly throwing over it sheets of foaming water." The highest part of the islet is close to the outer beach, and averages from six to ten feet above ordinary high-water mark.

At a distance of 2,200 yards from the breakers, Captain Fitzroy found no bottom with a line 7,200 feet in length; hence the submarine slope of this coral formation is steeper than that of any volcanic cone; and Mr. Darwin infers the existence of submarine cliffs from the sudden increase of depth at some points, and from the line having been cut as if rubbed at certain depths.

CHART AND VIEW OF THE ISLAND OF ASCENSION.

This island, which is entirely of volcanic origin, is situated in the Atlantic Ocean, in latitude 7° 55′ 56″ south, longitude 14° 28′ 50″ west, being about eight miles in length, and six in breadth. The mountain district extends principally over the south-east portion of the island; and the "peak," or highest elevation is 2,870 feet above the level of the sea. The plains or table-lands surrounding the "peak" vary in height from 1,700 to 2,600 feet. On the north side they sweep gradually down towards the shore; but on the south, they terminate in high and bold precipices. The hills dispersed over the island vary in height from 100 to 1,500 feet above the sea. They abound with cinders, scoriæ, and ashes, and are surrounded at their bases with compact and cellular lava, and occasionally obsidian.

The dark and rugged beds of lava, the deep red colour of the hills, the wild and capricious forms of the mountains and precipices, and the prevailing *apparently* recent indications of volcanic action, impart to the aspect of the island a character of total sterility and desolation that does not really belong to it. On approaching it, under a particular state of the atmosphere, when dark masses of clouds are congregated round the high peak and bosom of the Green Mountain, and their black shadows are projected far down the plains, so that the *only* evidence of verdure—the solitary oasis amidst the surrounding desolation—is shut out from the view, it is scarcely possible that the imagination should conceive a picture more wildly sublime."[10] Mr. Darwin, to whose instructive work we must refer for a geological description of the island,[11] mentions that from the central eminence he counted between twenty and thirty cones of eruption, the greater number of which had their truncated summits cut off obliquely, and they all sloped towards the south-east, whence the trade-wind blows; and in treating of the calcareous rocks on the sea-coast, he describes the accumulations of shells and corals, interspersed with volcanic particles, which are found cemented into stone, of which the softer varieties are used for building; and he states that in some of these formations, the eggs of the turtle being buried by the parent, sometimes become enclosed in the solid rock.

The chart of the island is reduced from the survey of Lieutenant Campbell, R.N.; and the view from the drawing by Captain Beaufreth, R.E., in the Journal of the Royal Geographical Soc., vol. v.

PLAN OF THE CRATER OF GEDEE IN THE ISLAND OF JAVA.

The volcano of Gedee is situated in the western part of the Island of Java, in latitude 6° 53′ south, longitude 108° 59′ east.[12] It is, according to Dr. Salomon Müller,[13] 9,728 feet in height. All the mountains of Java rise in the form of a tower above the general ridge of the island, which is proportionally of little elevation when compared with what many be reckoned at not more than 1,000 feet; so that the proportion between the height of the ridge and that of the peak is nearly as one to six.

This volcano affords an excellent example of an eruption cone, and we have succeeded in preserving in the annexed plan, which is reduced only about one-third from the original, all its picturesque and minute features. The most remarkable of these are the eruption cone and the small crater situated near its centre, which are surrounded on the east, south, and north, by a high ridge, somewhat in the shape of a horse's shoe, and from the interior of which immense streams of lava, occupying a breadth of upwards of 1,500 feet, have flowed in a northerly direction. The declivity of the crater is decked with shrubs and small trees of different kinds, and the valley of Aloen-Aloen is entirely overgrown with shrubs of *Gnaphalium Javanicum*.

This valley divides Goenong Gedee from G. Seda-natoe, the northern slopes of which support tolerably lofty trees.

This plan is from the survey of Dr. Salomon Müller, who with great kindness furnished a copy for the present work. The original appears in the magnificent work on the Natural History of the Possessions of the King of the Netherlands in the East Indies, now in course of publication.

PLAN AND VIEW OF GRAHAM ISLAND.

This remarkable volcanic island appeared in the Mediterranean in the month of July 1831, in latitude 37° 8′ 30″ north, longitude 12° 42′ 15″ east, about 33 miles north-east of Pantellaria; and remained visible above the surface of the water for about three months. About a fortnight before the eruption was visible, Sir Pulteney Malcolm, in passing over the spot, felt the shocks of an earthquake, as if the ship had struck on a sand bank; and the same shocks were felt on the west coast of Sicily. About the 16th July, the captain of a Sicilian vessel, in passing near the place, saw a column of water like a waterspout, 60 feet high, and fifteen in circumference, rising from the sea; and soon after a dense steam in its place, which ascended to the height of 1,800 feet. On returning, on the 18th July, he found a small island, 12 feet high, with a crater in its centre, ejecting volcanic matter, and immense columns of vapour. The eruption continued with great violence to the end of July, when it was visited by Captain Swinburne. On this time it was from 50 to 60 feet high, and three-fourths of a mile in circumference. By the 4th August it became, according to some accounts, above 200 feet high, and 3 miles in circumference. After this it diminished by the action of the waves, and was only 2 miles round on the 23th August. On the 3d September it was reduced to three-fifths of a mile in circumference, and 107 feet in height; and on the 29th September it was only about 700 yards in circumference. At the end of October no vestige of the crater remained, and the island was nearly levelled with the surface of the ocean. At the beginning of 1832 there was a shoal and discoloured water on the spot, but in the month of May no appearance of it existed, about three-fifths of a mile in extent. From the whole of the facts detailed by Mr. Lyell, he conjectures that a hill 800 feet in height was formed by a submarine volcanic vent, of which the upper part (about 200 feet high) emerged above the waters, so as to form an island. This cone, he says, must have been equal in size to one of the largest of the lateral volcanoes on the flank of Etna, and about half the height of the Mountain of Jorullo in Mexico, which was formed in the course of nine months, in 1759.[14]

PLAN OF ARTHUR'S SEAT.

Arthur's Seat, in the words of its geological explorer, to whose talented work we have much pleasure in referring for full and minute description,[15] "is an isolated hill, rising abruptly from a level country, to the height of 822 feet above the sea, with a bold craggy outline; and for grandeur and picturesque effect, is worth all the temples and monuments of London and Paris put together. It is so near Edinburgh, that it may be said to be in contact with the eastern parts of it. The lower part of the hill is chiefly of sandstone; the upper is entirely of trap—that is, of rocks of volcanic or igneous origin, of which the familiar name in this country is *whinstone*." Salisbury Craigs, so called from the fine mural precipice, formed by a bed of greenstone, is, properly speaking, only a part of the same hill, separated by the trifling hollow called the "Hunters' Bog." On the south side of the hill is the beautiful columnar precipice called "Samson's Ribs," of which we have given a vignette view. The plan represents the topographical configuration with greater accuracy than any other map of this interesting hill hitherto published, and the heights of all the principal points are the result of repeated and careful barometrical measurements. The sections are explained by reference notes and colours.

SOUTHERN VIEW OF ETNA FROM MONTE PO, NEAR CATANIA.

In the notes accompanying the large and beautiful drawing of which this is a reduction,[16] S. von Waltershausen has explained as follows the method he adopts for securing accuracy in his designs.

A certain number of points are to be arranged, proceeding from the eye through the central projection, as has been observed by Klein, in such a manner that each of the points in the picture is exactly determined by means of azimuth and height. The amount of both angles may be easily ascertained by the use of a theodolite furnished with a vertical arc; reckoning the projected points by taking the distance, or the length of the normal from the eye to the vertical plane, which the scale of the intended picture specifies. For this there is only a limited number of points necessary, in order that the picture may be receive the impression of reality; from every other point it appears more or less a distorted picture.

This drawing is based on nine fixed points, but the azimuths of fifteen other objects were connected with them, and their height and distance estimated. It embraces the whole of Catania, the Castle of Aci, the Scogli di Fiori, and is taken from M. Po, a low hill about two miles west of Catania.

It required a long study of the mountains in order to represent, in outline, the objects which are observed in this drawing, for some of the contours could only be perceived in the clearest sky, during favourable atmospheric relations, while others, on the contrary, were only distinctly visible so long as the higher regions were covered with a thick mantle of snow.

Etna is here seen from its southern side, where, without any considerable prominence, it upheaves from its base the gently inclined mass of lava, on which the still active crater has its seat, and from several wide vault, it rises and moves towards the distant Calabria. This phenomenon, of which S. von Waltershausen was an eye-witness on the 10th May, 1829, is here represented, in nature. On approaching somewhat nearer, in describing the surface of the mountain, we remark first the crater with its peaks, the form of which is observed to be involved in more constant change, according as the eruptions of the volcano reduce them to a level with itself. On the west side lies the lower highest point of Etna; to the east is observed a somewhat lower, sharp, steep peak, which bears the name of Il Dente; between the two lies the deepest part of the crater, which is called Pozzo di Fuoco. From this the lava of 1838 flowed to the foot of the cone, which, in November, 1842, was again partly overlaid by a new current.

The crater stands in the centre of a nearly horizontal plateau, on the southern margin of which lies the Casa Inglese; this is observed in the drawing as a nearly horizontal line, under which project two mountain peaks—on the west M. Frumento, and on the east Montagnuola. The last is the eruption-crater of the year 1763, which has spread itself over the ancient Piano del Lauro and Barile and Schiena dell'Asino. The Montagnuola forms the western end of the Serra del Solfizio, which, furrowed by several valleys, stretches out beyond M. Zoccolaro. Over these project the upper parts of Serra delle Concazze. The Valle del Boe or del Bove is enclosed by the two above-mentioned serras or mountain ridges.

Under the central mass of Etna we perceive, especially in the middle zone, a considerable number of lateral craters. Among those M. Rosso of Nicolosi, which is distinguished by two very characteristic pyramidal forms, appears to be the most ancient. From this crater, in the autumn of the year 1669, flowed the immense lava-stream, the wide extended track of which appears in the middle and foreground of the view. It breaks through the olive forests of the cultivated region in several branches, and, after it has passed Nicolosi, Trini and Valcorrente, and on the south towards Catania, where it reaches the sea. The surface of these black and naked streams of lava is, in the course of time, in some places, to bear a scanty vegetation of cactus, broom, and euphorbia, presents, far and wide, a picture of the most frightful desolation, and many centuries must elapse ere it can be again covered with forests and vine yards.

In the middle part of the mountain we perceive, in the wooded region, between the lateral craters, several other lava fields, which are so conspicuous as to attract the eye at a great distance. Towards the west is observed the current of 1780, which surrounds M. Parmenisidi, and stretches down to M. Mazzo and M. Ragabus.

Near the centre of the sheet lies another great lava field, formed by the currents of 1537, 1636, and 1766, from which several craters project. Lastly, more towards the east there appear three small branches, two of which originated in the year 1634; but the third, not far from Monte Urso, belongs to the eruption of the year 1792.

VIEW OF THE SUMMIT OF THE PEAK OF TENERIFFE.

This view is taken from a point the height of which is above the limits where all sorts of trees cease to grow, and is the true form of the last cone of the peak, which is seen in all its extent from so few points. On the left is perceived the steep rocks which form the circumference of the crater of elevation, the most elevated point of which is that of *los Azulejos*. This limit is continued circularly behind the first plane of the drawing.

Comparative View of the Elevation of the Principal Active Volcanoes on the Globe. These are arranged according to their occurrence in the Eastern or Western Hemisphere, and the elevation of each is indicated by the scale, in feet, above the level of the sea.

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[9] Journal Royal Geographical Society, vol. v. p. 263.

[10] Geological Observations on Volcanic Islands. London. 1844.

[11] See Map of the Volcanic Series of the Old World, sheet No. 7 of this division.

[12] The height is variously stated by other authorities. Dr. Junghun makes it 9,350 feet.

[13] Verhandelingen over De Natuurlijke Geschiedenis der Nederlandsche overzeesche Bezittingen, Door de Leden der Natuurkundige Commissie in Oost-Indie en andere schrijvers. Leiden: J. Luchtmans.

[14] Principles of Geology, vol. ii., p. 298. For further explanation see Mr. Maclaren's Geology of Fife and the Lothians, p. 67, and Description of the Plan and View, by Captain Swinburne, R.N., in Journal Royal Geographical Society, vol. v., p. 204.

[15] Geology of Fife and the Lothians, by Charles Maclaren, Esq., F.R.S.E.

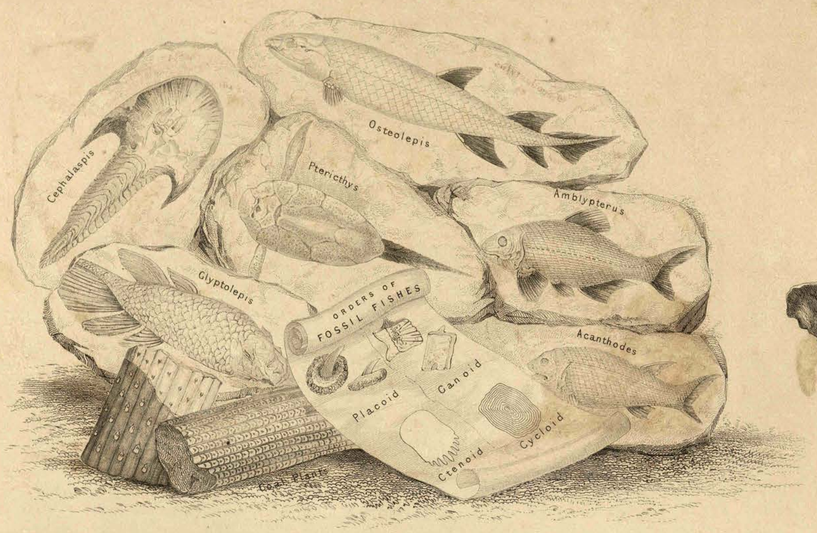
[16] Atlas des Etna, Vorwort und Erklärung der Kupfertafeln, s. 3.

PALÆONTOLOGICAL MAP
OF THE BRITISH ISLANDS.

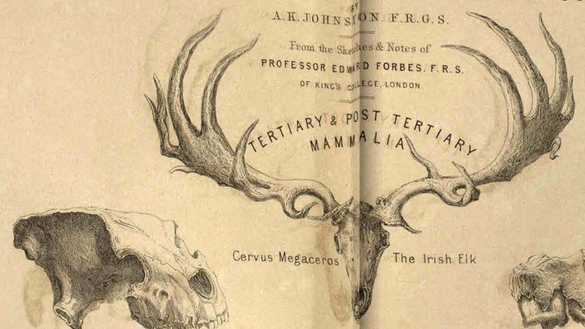
A.K. JOHNSTON, F.R.G.S.

From the Sketches & Notes of
PROFESSOR EDWARD FORBES, F.R.S.
OF KING'S COLLEGE, LONDON

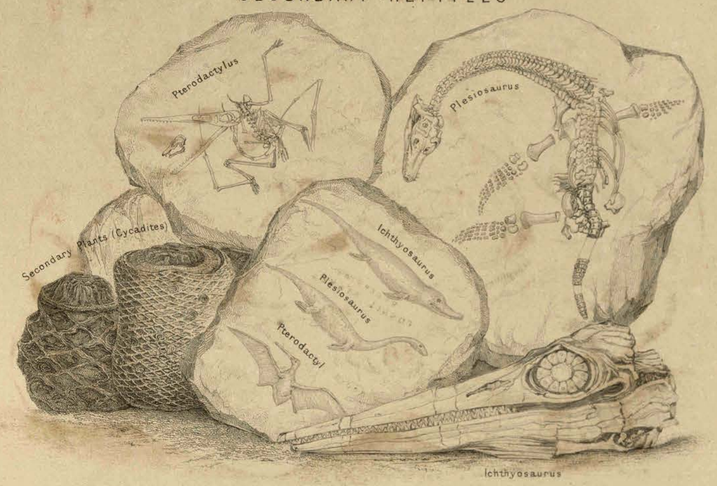
PALÆOZOIC FISHES

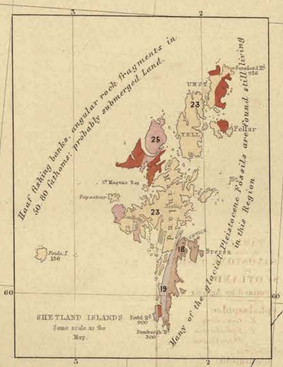


TERTIARY & POST TERTIARY MAMMALIA



SECONDARY REPTILES





Line of 100 fathoms

Sea frequented by Salpæ in summer

Line of 100 fathoms

Line of 50 fathoms

Line of 50 fathoms

Line of 100 fathoms

Line of 50 fathoms

Line of 15 fathoms

Line of 15 fathoms

Line of 50 fathoms

Line of 100 fathoms

Pleistocene Fossils dredged at Sea in this Region

Pleistocene shells of Arctic Mollusks frequently dredged in this region

Coal in Trap at Tallisker

Coal in Trap at Suisnish

Coal in Lias at Staffin

Lias of Burt Inish

New Red Strata near Belfast

L. Silurian Fossils at Girvan

Stems Asterophyllites, Sphenophyllum, Lepidodendron, Calamites, Neuropteris, Annularia, Sigillaria, Trigonocarpus, Cordaites, Stigmaria, Ferns, Coal Plants

Fishes of Pomona
Old Red Sandstone
Diplacanthus, Pterichthys, Holoptychius, Glyptolepis, Osteolepis, Cephalaspis, Coccosteus, Dendrodus, Pterygotus, Eurypterus

and resembling rocks of L. Erboll

O.R.S. Fishes

Cliffs of Pleistocene at Wick, containing boreal shells, especially Astarte borealis

O.R.S. Fishes of Elgin
Acanthodes, Holoptychius, Pterichthys, Placothorax, Dendrodus, Asterolepis, Stagonolepis, Lamnodus, Gyracanthus

Dolitic beds of Brora, containing numerous marine Mollusca, Belemnites, Ammonites, Trigonia, Ostrea, Pholadomya, Pecten, Avicula, Modiola, Cucullæa, Astarte, Pholas, Gervillia, Pentacrinus, Cidaris, Echinus, Cidarites, Apiocrinites, Millericrinites, Plesiosaurus, Ichthyosaurus, Teleosaurus, Pterodactyle, Wealden Fossils

M. O. R. S.

F.W. Wealden? beds near Elgin contain:
Fish Hybodus etc
Reptiles Plesiosaurus concavus
Mollusca Belemnites Ammonites cercalis in lst. Oolitic near Elgin

O.R.S. Fishes of Nairn & Cromarty
Pterichthys, Cheiracanthus, Coccosteus, Osteolepis, Diplacanthus, Diplopterus, Glyptolepis

Old Red Sandstone Fishes of Gamrie
Pterichthys, Cheiracanthus, Diplopterus, Chelonichthys, Glyptolepis

F.W.e.M.

Chalk flints in the vales probably from beds now overlying Shetland and Faroe in the Arctic Ocean

Old Red Sandstone Fishes of Caithness
Pterichthys, Coccosteus, Diplopterus, Dendrodus, Glyptolepis, Osteolepis, Cheiracanthus, Holoptychius, Phyllolepis, Asterolepis, Pterygotus, Eurypterus

Lias of Brora

Lias of Helmsdale

Lias of Port Gower

Lias of Lyme Regis

Lias in the form of micaceous Shale with inferior beds of small arenaceous blue Limestone

Lias of Dunrobin

Lias of Golspie

Lias of Invergordon

Lias of Cromarty

Lias of Tarbat Ness

Lias of Burghead

Lias of Lossiemouth

Lias of Findhorn

Lias of Cullen

Lias of Portsoy

Lias of Banff

Lias of Gamrie

Lias of Pennan

Lias of Aberdour

Lias of Inverkeithing

Lias of Dunbar

Lias of Eyemouth

Lias of Redcar

Lias of Whitby

Lias of Robin Hood's Bay

Lias of Scarborough

Lias of Filey

Lias of Flamborough

Lias of Bridlington

Lias of Hunstanton

Lias of Lincoln

Lias of Barton

Lias of Ancaster

Lias of Stamford

Lias of Rutland

Lias of Leicestershire

Lias of Warwickshire

Lias of Gloucestershire

Lias of Somersetshire

Lias of Dorsetshire

Lias of Devonshire

Lias of Cornwall

Lias of Glamorganshire

Lias of Monmouthshire

Lias of Herefordshire

Lias of Worcestershire

Lias of Shropshire

Lias of Cheshire

Lias of Lancashire

Lias of Yorkshire

Lias of Durham

Lias of Northumberland

Lias of Cumberland

Lias of Westmoreland

Lias of Lanarkshire

Lias of Ayrshire

Lias of Dumfriesshire

Lias of Kirkcudbrightshire

Lias of Wigtownshire

Lias of Argyllshire

Lias of Inverness-shire

Lias of Ross-shire

Lias of Sutherlandshire

Lias of Caithness

Lias of Orkney

Lias of Shetland

Lias of Isle of Man

Lias of Anglesey

Lias of Carnarvonshire

Lias of Merionethshire

Lias of Denbighshire

Lias of Flintshire

Lias of Montgomeryshire

Lias of Radnorshire

Lias of Brecknockshire

Lias of Carmarthenshire

Lias of Pembrokeshire

Lias of Cardiganshire

PALÆONTOLOGY OF THE BRITISH ISLES,

BY PROFESSOR EDWARD FORBES, F.R.S., OF KING'S COLLEGE, LONDON.

INTRODUCTORY NOTE.

The geology of the British Islands is more varied, and has been the subject of more minute investigation, than that of any other equal area on the earth's surface. It presents, in nearly continuous sequence, almost all the rocks characteristic of the successive geological epochs. Consequently it has become, in a great measure, the type of the geology of the earth; and the nomenclature of descriptive geognosy is in great part constituted out of the terms applied in Britain.

The practical investigation and right understanding of British geology dates from the commencement of the present century, and the labours of William Smith. The exertions of a distinguished body of enthusiastic investigators have brought it to its present perfection. The construction of a complete geological map of England was first effected by Mr. Greenough, the first president of the Geological Society. Scotland was first mapped as a whole by Dr. M'Culloch, and Ireland by Mr. Griffith. The working out of the geology of the British Islands, and the investigation of its economic applications is the task of the Government Geological Survey, now in progress, guided by the comprehensive views and experienced superintendence of Sir Henry De la Beche.

A great part of the surface of the British Isles is occupied by rocks which are of sedimentary origin, and fossiliferous. Igneous rocks occur in more limited tracts, and are present in considerable variety. Of the three kingdoms, Scotland is least prolific in organic remains, and is distinguished by the preponderance of older palæozoic rocks, the exact equivalence of the several links of which but yet to be made out, by the extent and importance of its newer palæozoic rocks, by the absence of the secondary and tertiary formations, and by the abundant development of igneous rocks which have in this region been investigated and defined with admirable precision, by Jameson and other eminent geognosts.

England presents but a comparatively limited display of older palæozoic strata in comparison with the area occupied by secondary formations, which form a most varied and extensive portion of her surface. The former, however, are considerably developed in their extreme members, the oldest and newest, and bear witness to the important part played by the latter in the composition of the strata in the composition of her surface. British tertiary strata are developed chiefly in the south-east of England. Wales is the seat of a great and most important development of the older palæozoic strata. Igneous rocks occupy but a small portion of the area of England and Wales.

Ireland is essentially a palæozoic country, covered in great part by the newest tertiaries or "drift." All other formations, whether aqueous or igneous, play but an insignificant part in her constitution. The great feature presented by Ireland, is the large portion of her surface occupied by the mountain limestone.

In the following table a concise view is exhibited of the fossiliferous formations in the British Islands, and their relations to those of other countries. In the second part of the text, we have given a systematic outline of the distribution and development of the various classes of organized beings during the successive geological periods.

I.—TABLE OF THE FOSSILIFEROUS FORMATIONS IN THE BRITISH ISLANDS, SHOWING THEIR MINERAL AND PALÆONTOLOGICAL CHARACTERS, AND THEIR RELATIONS TO FOREIGN ROCKS.

POST-TERTIARY

Principal Sub-divisions.	Mineral Character in Britain.	Chief British Localities.	Foreign Equivalents.	Palæontological Features in Britain.	Remarks and Species Referenced, chiefly Scotch.
A. Marine.	*Raised Beaches*, usually shingles or shelly sands.	All round the British coasts.	Similar raised beaches occur in most maritime countries; also submerged forests and peat bogs.	Shells, &c., such as now live in the British seas.	The references for plutonean formations equally apply to this division. Also, especially Strickland's Ichthyological Observations.
Terrestrial.	Peat-bogs are the principal. Submerged forests.	Occupying large tracts in Ireland and some parts of the Scotch Isles. The submerged forests are frequent around the coast.		Remains of Vertebrata, mostly such as now live or have formerly existed within our seas during the historical period.	
B. Fresh-water.	Blue or white shell marls, usually occurring below to the plutonean marine marls and below the peat.	In many parts of Scotland, the north of England, in the north of the Isle of Man, and frequent in Ireland.	In Northern Europe, and Boreal and Central North America, also Siberia.	Many of the bone caves have their place about this epoch. *The Megaceros Hibernicus* or Irish Elk is the characteristic fossil of these beds. Shells and vegetable remains occur in them, but all apparently of existing forms.	Owen's British Fossil Mammalia.

TERTIARY.

PLEISTOCENE.	1. *Glacial Beds.* Sands, gravels, and clay-marls, often stratified. 2. *Till.* Unstratified clays and gravels, with boulders. 3. *Macomalitforme or Norwich Crag.* Fossiliferous earth, shingles, and marl, partly of fresh-water origin. [The sands and clays of Bridlington are the equivalents of clauses 2 or 3.] 4. *Fresh-water beds.* Sands, marls, and gravels.	Generally present as drift over the greater part of Great Britain and Ireland. Fossiliferous beds occur chiefly in the North and in Ireland, Caithness and the Clyde region in Scotland, Lancashire in England, the Isle of Man, North Wales, and many parts of the south and east of Ireland. Norfolk is the region of the Macomalitforme crag, and the purely fresh-water beds (4) occur chiefly in Norfolk, Suffolk, Essex, and Kent.		The fossils found in the British marine pleistocene are chiefly remains of Mollusca. They are all of living British species now, chiefly found within the Celtic region, or such as, though still living within our seas, are only abundant in the Boreal region; as such as are extinct in our seas, but still survive in the same regions or on the coasts of Boreal America. A few southern forms, which do not now range to our seas, accompany them. The fossil mammalia of special beds, including the Mammalitforme crag, consists of above 120 species of marine Mammalia and Mollusca. In the fresh-water beds many extinct Mammals occur.	For the tertiary formations generally, the writings of Mr. Lyell are the chief authorities. For special information on the British plutoneans see Mr. Smith's papers in the Wernerian Memoirs and Geological Transactions; the papers of Sowerby, Trimmer, Bowerbank, Strutt, Gliddon, Griffith, and Hamilton, in the Irish Geological Transactions; and of Strickland, Martin Lanstborough, and Cumberland, in the English; also E. Forbes, in Memoirs of the Geological Survey, where a catalogue of the marine fossils of his deposit is given. The writings of Lyell and Bakewell on the American beds, and of Murchison on the Russian and Scandinavian; and of Phillips on the Sicilian N. F. fauna, should be consulted.
PLIOCENE.	*Red Crag.* Marine ferruginous sandy muds, and marls. The fresh-water (4) pleistocene beds may, in part, belong to this epoch.	The red and coralline crags occur chiefly in Suffolk.	The subsequently tertiaries are probably the equivalents of our red crag, and beds of the same age are found in several parts of the Mediterranean region. The brown coal beds of Germany. The Siwalik tertiaries of India.	In the red crag there have been found about 200 species of Mollusca, of which 99 are now known alive in the British seas; 61 of the number are plutoneans as well, and 10 of the 41 are species common to the coasts of Europe and Austrian. Zoophytes are five. The general character of our newest fauna and flora is tropical. With one or two exceptions all the species are extinct, and do not range to formations either above or below. The fullest catalogue of British newest fossils (Mr. Tennant's) gives the number as follows: Plants, 100; Zoophytes, 4; Echinodermata, 6; Foraminifera, 3; Annelida, 11; Cirrhipeds, 3; Crustacea, 4; Cirrhipeds and Brachiopods, 20; Gasteropods and Cephalopods, 267; Fishes, 31; Reptiles, 11; Birds, 1; Mammals, 14.	
MIOCENE.	*Coralline Crag.* Marine calcareous sands, limestone bands, and greenish marls.		The Touraine and Bordeaux tertiaries; the Vienna basin; certain beds in the Mediterranean islands, Spain, Portugal, and the north of Africa. Certain beds in Asia and North America.	The coralline crag abounds in shells and Zoophytes. Above 340 species of Mollusca have been collected in it, of which 180 are living British species. 39 of them are pleistocene forms. The general character of the fauna of this epoch is Lusitanian. Zoophytes abound, including many southern genera. The general character of our newest fauna and flora is tropical. With one or two exceptions all the species are extinct, and do not range to formations either above or below. The fullest catalogue of British eocene fossils (Mr. Tennant's) gives the number as follows: Plants, 100; Zoophytes, 4; Echinodermata, 6; Foraminifera, 3; Annelida, 11; Cirrhipeds, 3; Crustacea, 4; Cirrhipeds and Brachiopods, 20; Gasteropods and Cephalopods, 267; Fishes, 31; Reptiles, 11; Birds, 1; Mammals, 14.	
EOCENE.	1. *Hordwell Beds.* Loose sands, sandstone, marls, and shales. 2. *Bracklesham.* Limestones, alternating with marls, sands, and clays, partly marine, partly fresh-water. 3. *Barton Clays, and Bracklesham Beds.* 4. *London Clay and Bagshot Beds.* Dark clays, with septaria; sands and sandstones. 5. *Plastic Clays [and Woolwich fresh-water beds.]* Marls, sands, and shingles.	The Paris basin; the fresh-water eocene tertiaries of Central France; the Molasse of Switzerland; certain beds in Belgium and Northern Germany; some tertiaries in Western Asia and in India. Well-marked fossiliferous beds in both North and South America.		The fossils found in the British marine pleistocene are chiefly remains of Mollusca. They are all of living British species now, chiefly found within the Celtic region, or such as, though still living within our seas, are only abundant in the Boreal region; as such as are extinct in our seas, but still survive in the same regions or on the coasts of Boreal America. A few southern forms, which do not now range to our seas, accompany them. The fossil mammalia of special beds, including the Mammalitforme crag, consists of above 120 species of marine Mammalia and Mollusca. In the fresh-water beds many extinct Mammals occur.	
B. Middle or silt, and Limestone Strata	Coarse quartzose sandstones, and pebbly grits alternating in lamellæ with thin beds of bad coal. The lower part in places consists of laminated, and sometimes bituminous shales with thin bands of ironstone and limestone. Alternating beds of limestone, sandstone, and shale, take the place of the sandstone grit in part of Scotland.	Extensively developed in the north of England and Derbyshire. Found in Flintshire, Denbighshire, Shropshire, South Wales, Gloucestershire, and Somersetshire. Occupying a great part of the area of Ireland. In Scotland generally forming the lower beds of the Carboniferous series.	Foreign synonyms of carboniferous formations. Steinkohlengebirge. Terrain carbonifère. Terrain houiller. Terrain anthraxifère.		
C. Mountain Limestone.	Beds of limestone often very fossiliferous, hardly alternating with beds of grit, shales, and coal seams. In Ireland, consisting of two great beds of limestone with (in certain districts) a considerable thickness of shales and argillaceous limestones and sandstones between, forming the *culp*. The Irish mountain limestone runs into the Devonian series by the carboniferous shales and yellow sandstone of Griffith. In Scotland the coal-measures of Berwickshire are equivalents of mountain limestone. Beds of black limestone succeeded by siliceous flagstones, sandstones, and shales (*rocks*), constituting the calciferous measures of Devonshire.	Extensively developed in the north of England and Derbyshire. Found in Flintshire, Denbighshire, Shropshire, South Wales, Gloucestershire, and Somersetshire. Occupying a great part of the area of Ireland. In Scotland generally forming the lower beds of the Carboniferous series.	Berg kalk. Calcaire de montagne.	The mountain limestone abounds in fossils, especially remains of Mollusca and Radiata. There have been relationships with the Devonian species. The genus *Goniatites* is greatly developed in it, also peculiar forms of *Nautilus*, and many Gasteropods. *Productus Cora*, *productus*, and *sp. nov.* The curious *Macrocrinus* of the latter genus is common in Ireland, and *Poteriocrinus* and other genera occur, and corals in great plenty. The genera *Fenestella* and *Retepora* among Polyzoa, and *Phillipsia* among Trilobites, are characteristic. Fishes of many genera occur, *Holoptychius*, *Palæoniscus*, *Cheiracanthus*, and *Pucoliscus*, are frequent in certain localities.	Phillips' Geology of Yorkshire. Griffiths and M'Coy. Synopsis of the Carboniferous Fossils of Ireland. De la Beche and Conybeare on the Geology of Somerset. Dr. Kinnear's Carboniferous Fossils of Berwickshire. Agassiz and De Verneuil on the Geology of Russia. Owen's History of Kilkenny.
DEVONIAN.					
Old Red Sandstone.	Quartzose conglomerates, and hard fine-grained sandstones, alternating with marls in places. In Scotland the upper beds consist of quarry yellow sandstones, impure limestones, and earthy red sandstones. 2. *Cornstone and Marls.* Argillaceous sandy beds, alternating with sandstones and impure limestones, called cornstones, often including siliceous flaggy beds. In Scotland the middle beds consist of purple fissile sandstones, grey flags, and occasional marls. 3. *Tilestone.* Micaceous and quartzy greenish sandstones, with reddish shales. In Scotland represented by a series of beds, consisting of red sandstones, limestones, shales, and coarse grits alternating with marls, with a base of a thick conglomerate, extensively developed.	The old red forms a great tract in the borders of South Wales, and in the neighbouring English counties, and Hereford lies in its centre. Outlying patches occur in Radnorshire. A broad band of old red crosses Scotland from the Firth of Forth to the Firth of Tay, and northwards to Stonehaven. Considerable tracts occur in Berwickshire, Haddingtonshire, Ayrshire, and Lanarkshire. On the north, east it forms a large part of the country around the Moray and Dornoch Firths, the greater part of Caithness, the Orkneys, and part of Zetland. On the west coast it forms tracts in Sutherland, Ross, Skye, and Islay. In Ireland a large tract of old red occurs in Tyrone and Fermanagh. Others in Mayo, Sligo, Clare, Tipperary, and Limerick. Beds of it appear along the north portions of Kilkenny and Waterford, and are extensively developed in Cork and Kerry.	Devonian strata are extensively developed on the Continent. To the "big" old rocks on the right bank of the Rhine, between Wesbaden and the chain of the Taunus, to the Hars district, and in the northern flank of the Fichtelgebirge." They include a series of shales, slates, and limestones, containing many fossils identical with those of South Devon. In Belgium and the Eifel, and elsewhere on both banks of the Rhine, Devonian strata are largely developed. In Russia the old red sandstone occupies a large expanse. In the United States, and in Canada, are beds of the same age. The peculiarly limestones of Australia and Van Diemen's Land appear to be equivalents of the Devonian. (See Strzelecki on Australia.)	Remains of Fishes are most characteristic of the old red sandstone at home (as tribes or *Magi*) and abroad; but have been found also among fossils of various localities. The presence of *Holoptychius nobilissimus* in the upper beds, of *Cephalaspis* and *Onchus* in the middle, and of *Diplopterus*, *Pterichthys Cornutus*, &c., in the lower, of Scotch old red sandstone, characters for certain beds. Remains of Fishes are much more abundant in the Scotch than in the English beds. Invertebrate remains are very rare in the former, and only frequent in the lower beds of the latter. Agassiz regards the Devonian Fishes as representing the embryonic state of Fishes. They are all either Ganoids or Placoids. The Devonian strata of Devonshire contain abundant fossils, more especially Mollusca, Crustacea, and Zoophytes. (See works of Phillips, and of D'Archiac and De Verneuil.) The latter are very numerous. So are the Brachiopoda; and among them we find certain forms, such as the genus *Strigocephalus*, especially characteristic of this formation. The general assemblage of Devonian fossils decidedly like the Silurian, with the exception that several species are common to the Devonian, and the beds above and below. Fishes are comparatively rare.	On the old red sandstone of England consult Murchison's Silurian System. On that of Scotland, see Hugh Miller's Old Red Sandstone, and the writings of Lyell, Maclochlan, and Powrie, in Jameson's Journal. See Agassiz, Monographs of the Fishes of the Old Red Sandstone. On the Devonian beds of England consult Murchison and Sedgwick's Memoir on Devonshire, in the 5th vol. of the 2d series of the Geological Transactions; the Geological Report on Devon, &c. of De la Beche; the Palæontology of Devon, by Phillips; the papers of Austen and Lonsdale. The Memoir of Murchison and Sedgwick on the Rhenish Provinces; the work of Rozmert, and the "Geology of Russia," for Continental information.
DEVONIAN SUBS.	A. Coarse red flagstone and slates. B. Calcareous slate, limestone, arenaceous beds and conglomerates.	In the west of Somerset, the south of Devon, and a great part of Cornwall.			
SILURIAN.	[DIVISIONS AS PROPOSED BY MURCHISON.]	The Upper Silurians are chiefly developed in the borders of Wales, the counties of Denbigh, Salop, Montgomery, Radnor, Brecknock, and Carmarthen. Patches form the Malvern, and other tracts in Gloucestershire, Hereford, and Worcestershire; also at Dudley and Walsall in Staffordshire. They are extensively developed in the lake district. Some of the Silurian tracts of the west of Ireland, and part of the chain of Kinkers, are clearly upper.	Silurian strata are extensively developed in the north of Europe (Norway, Sweden, Russia, and Westphalia, Bohemia, Brittany). They have been discovered by Pentland in Bolivia and Peru, and by Aitch on the flanks of the Andes. In North America they are very extensively developed, and have been examined by American geologists in great detail. All these Silurian districts may be regarded as limited palæontologically by numerous species in common with the Silurian formations of our own country. They appear to exist in South Africa, China, Tierra del Fuego, and the Falkland Isles, but it is too improbable that the palæozoic deposits of the southern hemisphere do not correspond with those of the northern as to duration in time.	Great interest attaches to the palæontology of the Silurians, on account of their presenting us with the most ancient and organized beings. Representatives of all the great types of life are present in them, but not of all kinds; and the existence of the lowest is not evidence of Fishes. All the sections of the Sedimen are present, and the Mollusca are the prevailing. Trilobites are the principal and most characteristic of Crustacea in these beds. Corals are also abundant. Fishes, however, appear to have been deep-sea formations. The species of the Silurians are characterized palæontologically, as follows:— a. Holoptychius Nobilissimi and Lucherni, Serpulites longissimus, Lingula lamina, Orbicula rugata, Siowella crenulata, Orthoceratites, Trochi, and other species. Chonetes acuticostata, and Terebratula sarcinula, are abundant and characteristic forms. b. Atrypa affinis, Pentamerus Knighti, Terebratula Wilsoni, and Lingula Lewisii. c. Cardiola, Lingula lata, Pterinea aeuta, Llandeilo Orthoceratites Cranii, Pterygotes anglicus, Graptolites and Trematidæ innate. d. Graptolites of swords and Tetholites (Calymene and Dalmanites especially characteristic), frequency of Lapteus cephalus and depressus. Numerous other Brachiopoda, Cephalopoda, Gasteropoda, and Crustacea. e. Terebratula Striickiandi, Amplexus lunge-caudatus, Orthis elegans, Spirifer elevatus, Leptæna transversalis, Syringothus. f. Trilobites, Leptæna sericea, Orthis alternata, lentaDiscria, &c. (Orthis elegantula abundant), Pentamerus laevis, Terebratulæ nucleatus. g. Upper Bucchi, Asaphi notus, Lingula arenaria, Orthis Actoniæ, Graptolites foliaceus and Murchisoni. Many of the above fossils range through several or all the beds, and connect the parts of the system.	Sir R. Murchison on the Silurian System. The Memoirs by Sir Henry De la Beche and Professor Sedgwick, in the Memoirs of the Geological Survey. Griffith and M'Coy, Synopsis of the Carboniferous Fossils of Ireland. Portlock's Report on the Geology of Londonderry, &c. The papers of Sedgwick, Horner, Lyell, Sharpe, Bowman, Cumming, Salter, Taylor, &c., in the publications of the Geological Society. Davidson in the London Geological Journal. Harcourt's Trilobites. For foreign information see "the Geology of Russia," the writings of Swedish naturalists, the works of Von Buch, Lyell, De Verneuil Bickwald, Pander, Barrande, the American Geological Reports, &c., &c.
LOWER PAL.-SEDIM.	B. Lower Silurian. (And Cambrians of Sedgwick.)	Lower Silurians, and Cambrian rocks, are most extensively developed in Wales, and occur in small patches in Cornwall, and in some of the central English counties, either with or without overlying beds. They are extensively developed in the lake district and in the south of Scotland; also in and around the county of Louth in Ireland, and in Wicklow, Wexford, and Waterford. Other tracts occur in the centre and west of Ireland. The Isle of Man is chiefly composed of Cambrian rocks.			

* This beautiful series of fine Geological Survey of Great Britain.

PALÆONTOLOGICAL MAP

SHEET Nº 2

Petalodus
(Northern limits of Echinus lividus)
Silurian at Ponsey
Brongniartides &
Incertæ Ribesiacæ
Lonchus latibasis
Lonchus gigas
rectifrons
Halonia
Illaenus etc.
Pleistocene clays with glacial shells
Megaceros in post Pleistocene beds
Tapes pullastra &c.
Cardium edule &c.
Carboniferous limestone
with its fossils
Line of 15 fathoms
About 170 invertebrata
in the U.S.I. Silurian
of Westmoreland
(including asterias
Protaster, Cystidea &
many new Mollusca
& Trilobites.)
Carb. Lim.st at Kendal &
Holland, rich in fossils
including Protremites &
many peculiar crinoids.
(This region was probably land
during the epoch of the Irish Elk)
Fauna of the Irish Sea, or
that pleistocene origin &
characteristically of the
Celtic type)
Line of 15 fathoms
Graptolites priodis or Sloan
Orthis pentagonoides
& 5 other Brachiopoda
at Craigegeeth
Silurian Fossils
Zoophyta and Brachiopoda
Orthisgalaea porcata
and terebratuliformis
Trilobites of Chair of Kildare M.S
Harpes obtusus
Terebratula intermedia
Cheirurus (5 Species)
Sphaeroconchus Portlocki
Acidaspis bisgranata
Lichas Hibernica
lunata
Homalonotus Knightii
Illaenus Bowmanni
Line of 45 fathoms
Cheirotherium, Footsteps
Greatest elevation of
Pleistocene Shells at
Moel Tryfan, 2020
feet above the sea.
Graptolites priodis ?
Encrinites in Limestone Rock
(Limit of Cytherea chione
Northwards)
Submarine Forests
Submerged forests
Submarine Forests
Drag Fossils
are dredged in
this Sea.
Submarine Forests
Submerged forests
Submerged forests
Submerged

II. DISTRIBUTION OF ORGANIZED BEINGS IN TIME, ESPECIALLY OF THOSE PRESERVED IN BRITISH STRATA.

VERTEBRATA.

MAMMALIA.

The oldest remains of Mammals date as far back as the oolitic period. They are Marsupial quadrupeds, *Amphitherium Broderipii*, *Amphitherium Prevostii*, and *Phascolotherium Bucklandi*. They occur in the Stonesfield slate, and as yet but few relics of these interesting extinct creatures have been found.

The next evidence of the presence of Mammals within our area is furnished by the London clay, chiefly by the fresh-water or fluvio-marine beds of the Isle of Wight. The following British Eocene Mammalia have been recorded, all the species and most of the genera being extinct:—

Macacus eocenus, Owen.
Anoplotherium commune, Cuvier.
——— *secundarium*, Cuvier.
Charopotamus Cuvieri, Owen.
Dichobune ovina, Owen.
Palaotherium crassum, Cuvier.
——— *curtum*, Cuvier.
——— *medium*, Cuvier.
Palaotherium minus, Cuvier.
Hyracotherium cuniculus, Owen.
——— *leporinum*, Owen.
Microlestes crassus, Charlew.
Spalacodon ——? Charlew.
Lophiodon minimum, Owen.
Dolichis Cuvieri, Owen.
Coryphodon eocenus, Owen.

In the upper tertiaries it is difficult to draw definite lines between such of our Mammals as belonged to the pliocene and perhaps miocene epochs, and such as lived during the pleistocene, and the commencement of the present. Many of them appear to have lived through all; others to have inhabited our area during the pliocene, deserted it during the pleistocene, and to have again returned; some to remain even until now, others, from causes not yet very clearly made out, to have become extinct before man's away in these regions. Peat-bogs, pits of fresh-water marl, and above all, ancient caves, have supplied most of the remains of our later tertiary and post-tertiary Mammals.

The principal forms, either entirely extinct, or extinct within the British area, found under such circumstances, are the following:—

QUADRUMANA: *Macacus pliocenus*.

CARNIVORA: *Hyæna spelæa*, *Felis spelæa*, *Felis pardoides* (in the mammaliferous crag). *Machairodus latidens*, *Ursus arctos* (extinct so far as Britain is concerned), *Ursus priscus*, *Ursus spelæus*, *Canis lupus* (extinguished in Britain within record of history).

RODENTIA: Species of *Arvicola*, *Castor Europæus* (extinguished in Britain within record of history), *Troyontherium Cuvieri*.

PACHYDERMATA: Species of *Mastodon (angustidens* in mammaliferous crag), *Elephas primigenius*, *Hippopotamus major*, *Rhinoceros leptorhinus* and *tichorinus*; *Sus scrofa* (no longer wild in Britain), two species of *Equus*.

RUMINANTIA: *Bison*, two species, *Bison minor*, and *Bison priscus*; *Bos longifrons*; *Cervus caryocerus*, *Tarandus* and *Megaceros*; *Strongyloceros spelæus*.

CETACEA: Several apparently extinct species of *Balænæ*.[1]

In foreign countries no fossil Mammals have been discovered in formations older than the tertiary epoch. In the Paris basin numerous species have been found of the eocene age. During the later tertiary epoch, and previous to its pleistocene stage, numerous Mammals appear to have existed in all parts of the world. Auvergne, Aix, and Oeningen, are the chief European localities for their remains. Several of the more characteristic eocene genera, especially of Pachyderms, no longer appear in beds of this period. Ruminants become very numerous, and Carnivora increase. Among European animals of this time were some very extraordinary forms, especially the *Macrotherium* and the *Dinotherium*. The strata of the Sivalic Hills in India, so rich in remains of Vertebrata, many of them very extraordinary forms, a knowledge of which we mainly owe to the enterprise and research of Dr. Falconer and Major Cautley, were most probably formations of the later tertiary epoch, and perhaps continuous even to the post-tertiary time. The great number of species of Pachydermata, especially of elephant, and the presence of extinct genera of Mammals, such as the *Sivatherium*, give a peculiar feature to the ancient Sivalic fauna. The presence of numerous extinct forms of Mammals, both genera and species, along with gigantic extinct Reptiles, and others undoubtedly identical with existing Indian species in their Indian formations, is certainly one of the most interesting facts ever made known through palæontological research.

In caves and drift, not a few pleistocene and post-pleistocene Mammals have been found on the continent of Europe, most of them identical with such as are found under similar circumstances in Britain. The Mammoth of Siberia is an instance of a pleistocene Mammal being preserved entire in a frozen soil. Other remains of the same age occur in the north of Asia. In the south of Africa, it would appear that Mammals of pleistocene and post-pleistocene age exist. In North America they are almost identical with those of Europe; but in South America an immense and peculiar assemblage of Mammalia occurs, especially in bone caves in Brazil, with the contents of which Dr. Lund has made us acquainted, and in certain deposits of the Pampas, and extreme south, explored by Mr. Darwin. The presence of gigantic Edentata, such as the Megatherium, Megalonyx, Mylodon, and Glyptodon, is the most remarkable feature of the South American pleistocene fauna, which seems curiously to have represented, though on a grander scale, the actual zoological *facies* of the province.

The following table will serve to exhibit the extent of development of generic forms of Mammalia, during the several geological epochs.

TABLE OF RECORDED GENERA OF FOSSIL MAMMALIA.

Pliocene and Miocene Tertiaries.	Oolitic Formations.	Cretaceous.	Eocene Tertiaries.	Miocene and Pliocene Tertiaries.	Pleistocene and Post-pleistocene Strata.
					Extinct forms of
0?	Tritylodontherium. Phascolotherium.	0?	Macacus.	Sivatherium?	Ursus.
			Vespertilio.	Semnopithecus.	Hyæna.
			Midas?	Erinaceus.	Viverra.
			Taxotherium.	Sorex.	Canis.
			Palæryon.	Mygale.	Lupus.
			Canis.	Talpa.	Lagomys.
			Viverra.	Ursus.	Elephas.
			Microcharus.	Amphicyon.	Hippopotamus.
			Sciurus.	Amphicticeus.	Sus.
			Myoxus.	Canis.	Rhinoceros.
			Charopotamus.	Hyænodon.	Rhinoceros.
			Hyracotherium.	Viverra.	Sivatherium.
			Lophiodon.	Felis.	Mastodon.
			Palæotherium.	Antilope.	Cervus.
			Amphitherium.	Bos.	Antilope.
			Dichobune.	Phoca.	Bos.
			Adapis.	Arctomys.	Ovibos.
			Delphinus.	Myoxus.	Hippopotamus.
			Didelphis.	Hyracotherium.	Elephas.
			Coryphodon.	Thylacinus.	Equus.
				Archæotherium.	Castor.
				Macropus.	Arctomys.
				Cricetus.	Lepus.
				Hyrgaxyrtron.	Felis.
				Plesiodimeryx.	Canis.
				[The last five genera in Australia, besides numerous still existing species belonging to various genera.]	Hyæna.
				Macrotherium.	Ursus.
				Elephas.	Elephas.
				Mastodon.	Mastodon.
				Hippopotamus.	Hippopotamus.
				Hyotherium.	Sus.
				Anthracotherium.	Rhinoceros.
				Rhinoceros.	Equus.
				Tapirus.	Tapirus.
				Lophiodon.	Macrauchenia.
				Palæotherium.	Toxodon.
				Anoplotherium.	Dinotherium.
				Charotherium.	
				Chalicotherium.	
				Oplotherium.	
				Colenotherium.	
				Hippotherium.	
				Equus.	
				Camelus.	
				Dromotherium.	
				Cainotherodactylus.	
				Dromotherium.	
				Cervus.	
				Antilope.	
				Capra.	
				Bos.	
				Sivatherium.	
				Antelope.	
				Dinotherium.	
				Metaxytherium.	
				Delphinus.	
				Physeter.	
				Balæna.	

Add to the above the following genera, of which species are found in deposits probably of the same age in South America:

Cebus.
Callithrix.
Protopithecus.
Isothrix.
Dypogus.
Hydrochœrus.
Viscacitherium.
Ursus.
Nasua.
Canis.
Spectbos.
Gnu.
Mephitis.
Hyæna.
Felis.
Cynodictus.
Lagostomus.
Auchenia.
Solenops.
Echinys.
Lonchipborus.
Cercomys.
Hoplerpeys.
Myopotamus.
Synetherus.

Extinct forms of
Lepus.
Anoxys.
Kerodon.
Chlamyphorus.
Cadogenys.
Hydrochœrus.
Megatherium.
Megalonyx.
Mylodon.
Scelidotherium
Colodon.
Scleredon.
Glyptodon.
Hoplophorus.
Pachytherium.
Chlamydotherium.
Dasypus.
Eutydon.
Heterodon.
Orycteropus.
Glossotherium.
Elephas.
Mastodon.
Sus.
Dicotyles.
Tapirus.
Macrauchenia.
Toxodon.
Equus.
Anchenia.
Cervus.
Antilope.
Leptotherium.
Bos.
Zeuglodon.
Didelphis.

AVES.

The first traces of Birds are to be found in certain impressions on sandstones, probably of Permian age, in the state of Massachusetts. They are supposed to be foot-prints, and have been named Ornithichnites. No such markings have been as yet observed in Britain. Our earliest supposed Bird is the *Cimoliornis Dixonlensis* of Owen, from the chalk of Maidstone. On the Continent remains of Birds of two epochs have been found in the peculiar cretaceous shales of Glaris in Switzerland. The *Lithornis vulturinus* is a British eocene fossil bird. Several eocene remains of this class have been found on the Continent. In the newer tertiaries also both at home and abroad remains of Birds occur; but we have reason to believe that our knowledge of this part of the Vertebrate fauna of any former period is at present very unsatisfactory and incomplete.

The most remarkable extinct Birds which have yet been found are those of the gigantic *Dinornis* and its congeners, which appear to have existed in post-pleistocene times, probably at an epoch corresponding with that of the Irish elk in our own country.

REPTILES.

The oldest remains of Reptiles in British strata are found in the magnesian conglomerate of Bristol. The *Palæosaurus cylindrodon*, and *Palæosaurus platyodon*, and the *Thecodontosaurus antiquus*, all made known by Dr. Riley and Mr. Stutchbury, are the species therein found. They are Lizards.

In the upper new red sandstone, or trias, we find the number of remains of Reptiles increase; members of several families, viz., Chelonians, Batrachians, Lacertilians, and Enaliosaurians. The presence of members of the second, or Frog tribe, is a remarkable feature of the trias. Six species of the extraordinary Batrachian genus, *Labyrinthodon*, have been described by Owen; and the *Chirotherium Herculis* of Egerton would seem to be the foot-prints of similar animals. *Cladyodon* and *Rhynchosaurus* are other remarkable reptilian genera of this formation; and in Scotland and Cheshire foot-prints of *Testudo* and of *Rana* have been observed on the surface of new red sandstone beds.

The British lias is a store-house of fossil reptiles. In it we find the greater number of those extraordinary creatures the *Ichthyosaurus* and *Plesiosaurus*. No fewer than nine species of the former genus, and eleven of the latter, have been collected in beds belonging to this part of the oolitic formations. Lyme Regis, Whitby, and Aust Cliff, are among the localities most prolific in their remains. With them, at the first-named place, occurs the *Pterodactylus macronyx* of Buckland. *Teleosaurus* and *Hyosaurus* are also British liassic Reptiles. Other oolitic Reptiles are the *Plesiosaurus* (Owen), of which two species occur in the Kimmeridge clay; the *Steneosaurus* from the same beds, the *Streptospondylus Cuvieri*, and the *Cetiosaurus longus* and *medius*), species of *Ichthyosaurus* and *Plesiosaurus*, occur also in the Kimmeridge; and *Pterodactylus Bucklandi* is from the great oolite, as also *Teleosaurus Cadomensis*. (*Teleosaurus subcadomensis* is a Kimmeridge species.) The *Megalosaurus Bucklandi* is found in the great oolite at Stonesfield; and remains of *Emys*, *Chelonia*, and *Lacerta*, are recorded from oolitic beds.

The fresh-water beds of the Wealden have furnished many remarkable Reptiles; for a knowledge of which we are indebted to the indefatigable researches of Dr. Mantell. Two species of *Chelonia*, a *Platemys* and a *Trionyx*, species of *Megalosaurus* (the same with that in the great oolite), *Suchosaurus*, *Hylæosaurus*, *Goniopholis*, *Streptospondylus*, *Poikilopleuron*, *Cetiosaurus* (two species), and the wonderful *Iguanodon Mantelli*, constitute our British Wealden reptilian fauna.

In British cretaceous beds a number of fossil Reptiles have been found. The *Pterodactylus giganteus* of Bowerbank, the *Iguanodon Mantelli*, the *Plesiosaurus pachyomus*, and the *Mosasaurus Hoffmanni*, may be regarded as most interesting. The other genera are *Raphiosaurus* (one species), *Polyptychodon*, *Leiodon* (one species), and *Chelonia* (two species).

The Reptiles of our tertiary strata are chiefly Turtles. Eight species of *Chelonia*, one of *Emys*, and one of *Platemys*, have been found, chiefly in the clays of the island of Sheppy. In the same locality the remains of a snake, the *Palæophis toliapicus* of Owen, are not uncommon. A crocodile (*C. Spenceri*) has been described by Dr. Buckland, from Sheppy and Begnor; another has been discovered by the Marchioness of Hastings at Headwell; and an alligator has been announced by Mr. Searles Wood from the same locality. Thus it would appear that our eocene reptilian fauna was of a tropical character, even as the Mammalian and invertebrate faunas of that epoch, and as the plants appear to have been.[2]

No remains of Reptiles have as yet been found in our upper tertiaries. But in equivalent beds abroad numerous forms have occurred. One of these is the celebrated fossil salamander (*Andrias Scheuzeri*), once supposed to be human. The extraordinary gigantic tortoise of India, *Colossochelys* of Falconer and Cautley, also takes place there.

In the accompanying table a full list is given of the genera of Fossil Reptiles.

TABLE OF RECORDED GENERA OF FOSSIL BIRDS AND REPTILES.

Birds, Reptiles, Batrachians, Chelonians.	Permian.	Trias.	Oolitic Formations, and Wealden.	Cretaceous Formations.	Tertiary Eocene.	Tertiary and Tertiary Formations.	Pleistocene.
			REPTILES.				
0?	Protorosaurus. Thecodontosaurus. Palæosaurus.	Testudo. Chelonia. Emys. Platysaurus. Ichthyosaurus. Plesiosaurus. Nothosaurus. Dracosaurus. Cladyodon. Rhynchosaurus. Labyrinthodon. (Chirotherium?) Dicynodon.	Testudo. Emys. Trionyx. Platysaurus. Ichthyosaurus. Plesiosaurus. Nothosaurus. Ichthyosaurus. Plesiosaurus. Teleosaurus. Cetiosaurus. Geosaurus. Suchosaurus. Hylæosaurus. Iguanodon. Goniopholis. Pterodactylus. ——— All extinct species.	Chelonia. Platemys. Mosasaurus. Leiodon. Raphiosaurus. Iguanodon. Polyptychodon. Pterodactylus. ——— All extinct species.	Testudo. Emys. Trionyx. Chelonia. Platemys. Crocodilus. Palæophis. ——— All extinct species.	Testudo. Emys. Trionyx. Chelonia. Chamesaurus. Crocodilus. Ophis. Boa. Bungharus. Amblyrhynchus. Tribus. ——— All extinct species, except the Indian Crocodile and Tortoise.	The five species known are identical with existing forms.
			BIRDS.				
	Footsteps of Birds.			Chalcibeels and others undetermined.	Lithornis and Gastornis undetermined.	Remains of Birds, but undetermined.	The species known apparently identical with existing forms, except the Dinornis.

PISCES.

The remains of Fishes in British Silurian strata are obscure, and consist chiefly of species supposed to have belonged to the Placoid order. The genus *Onchus*, specimens of which have occurred in both lower and upper Silurians, is an example.

The old red sandstone is a great store-house of fossil fishes. All the species are either Ganoids or Placoids. Of the former above sixty species have been described, chiefly by Agassiz. These belong to twenty-six genera.—(*See tables engraved on Map.*)

The number of our Fishes of the carboniferous epoch is very great. Many, however, still remain to be described. Twenty-four species of Sauroid Fishes are among those enumerated; twelve of Ganoid, and nearly a hundred of Placoid. The limestones of Bristol, Armagh, and the Hook-point, in Wexford county, are rich localities for carboniferous Fishes.

The Fishes of the Permian strata are few in number.—(*See Map.*)

In the upper new red sandstone, or trias, we find sixteen species of Placoid and seven of Ganoid Fishes.

The oolites, especially the *lias*, are rich in remains of Fishes. The principal genera are, among Placoids, *Hybodus*, with sixteen species; *Acrodus* (8), *Strophodus* (3), and *Chimæra* (11). Among Ganoids, *Depedius* has six British representatives, *Tetragonolepis* (12), *Lepidotus* (10), *Pholidophorus* (11), *Eugnathus* (10), *Pachycormus* (9), and *Pycnodus* (8).

In the Wealden, species of *Acrodus*, *Hybodus*, and *Sphenonchus* occur among Placoids; and of *Tetragonolepis*, *Lepidotus*, *Pholidophorus*, *Ophiopsis*, *Gyrodus*, and *Pycnodus*, among Ganoids.

In our cretaceous rocks Placoid Fishes are most numerous. Between thirty and forty species are recorded. The genera *Ptychodus* and *Chimæra* (or an allied type) are most prolific in species. Between fifteen and twenty Ganoids occur, *Gyrodus* and *Pycnodus* being the principal genera. Of *Ganoids*, there are three species belonging to the genus *Beryx*, and of *Cycloids* ten species, belonging to nearly as many generic types.

[1] For the fossil British Mammalia of this and other periods, Professor Owen's "History of British Fossil Mammals and Birds" should be consulted.

[2] See Owen's Reports, in Reports of British Association.

Principal Sub-divisions.	Mineral Characters in Britain.	Chief Strata Localities.	Foreign Equivalents.	Palæontological Features in Britain.	General and Special References, chiefly British.
LOWER SECONDARY—Continued.	LOWER OOLITES.	1. *Cornbrash.* This coarse rubbly limestone, with clays and sandstones. 2. *Forest Marble.* Shelly limestone, capping sandy clays and calcareous grits/stone. 3. *Bradford Clay.* Pale grayish clay, alternating with bands of tough brownish limestone. 4. *Great Oolite.* Oolitic shelly limestone of various degrees of compactness, alternating with limestone with oolitic structure, and shales. Locally (in Yorkshire) a hard lime limestone with oolites, sandstones, and shales, charged with fossil plants. 5. *Stonefield Slate.* Calcareous, shelly, and gritty flagstones. 6. *Fullers' Earth.* Stiff blue clay, with bands of shelly limestone. 7. *Inferior Oolite.* Hard rubbly limestone, and soft freestones, marls, and sands, locally (to the north of England) sandstone and ironstone.	The lower oolites accompany and occupy a corresponding tract with the middle oolites, and appear in like manner in Yorkshire. The lower oolites occupy small tracts in Cotteswold and the Hebrides.	The divisions of the inferior oolites are all more or less distinctly represented in Normandy. There the lower marbles is known as the "Calcaire à Polypiers," on account of the number of corals contained in it; the great oolite is the "Calcaire de Caen," and the inferior oolite preserves its name. The inferior oolites are represented in the Jura by limestones alternating partly with marls and clays, and partly with shales and ferruginous bands. In Franconia the lower oolites are represented by marly beds. The relationship of the Arctic oolitic strata with the lower and middle oolites is very obscure. In South America certain cretaceous strata, forming the transmontane oolitic series of Darwin, seem to represent the whole of the oolitic and cretaceous epochs. A. D'Orbigny's "Etage Bathonien" is equivalent to our lower oolites. In Germany, the terms walker-erde, dogger, and oxfer-oolith, are applied to our fullers' earth and inferior oolite. The terms jura kalk, and grosse Jurakegue, are very generally applied on the Continent to the oolite formation.	Bivalves are the most abundant Mollusca in the term-branch. *Pholadomya Murchisonæ* is one of the most widely distributed. *Ammonites Humphriesianus* is peculiar to this bed. Also *Ammonites discus*. Though the subclasses of the Great mollusks mainly consists of organic remains, few species are described from it. The Brachiopoda are numerous. The Echinodermata, *Pentacrinites, Tiloscrinus*) occur in it; also Fishes. Above 60 species of Acephalous Mollusca are recorded from this formation, and about half the number of Gasteropoda, but few Cephalopoda. A considerable number of Echinodermata occur, and no fewer than nearly 40 Radiata, of various orders. In this Neozoic division the only oolitic Mammals have occurred, viz., the *Phascolotherium* and *Bolinodontes*, numerous Fishes are found in this bed; and Reptiles also occur. Few fossils are found in the Fullers' earth; but the inferior oolite abounds with organic remains, chiefly of Invertebrata. In it we find the greatest assemblage of oolitic Cephalopoda; and the other orders of Mollusca are equally developed. Considerably over 100 Britain species are recorded. The number of Radiata, however, is much less than that contained either in the coral rag or great oolite. *Ammonites Banksii, Brocchii, Brodiii, serrospina Murchisonæ, Sowerbii, and Sauzeanus*, are peculiar species. The fish is very rich in organic remains. Many species of Saurians occur in it, and abundantly. *Teleosaurus* and *Pliosaurus* are common in it. Fishes are numerous, and very characteristic. Mollusca are generally plentiful. Above 170 species have been described from British Jurassic. Acephalous are especially abundant. Gasteropods are numerous. *Ammonites Banksii, Gowerianus, Brocchii, Conybeari, Humphriesi, Brongniartianus*, and numerous, are characteristic species. Belemnites are common, and remains of cuttlefishes. *Nautilus hexagonus* is a characteristic bivalve. *Pentacrinites* are abundant, and the Echinoidea generally are not equal to the Mollusca in proportion of development. Star-fishes are frequent in the sandstone. Plants are frequent.	See Buckman in Geological Proceedings, vol. iv. Owen, in the 6th vol. of the Geological Transactions, 2d series, and in his British Fossil Mammalia.
	LIAS.	1. *Upper Lias Shale.* Loose shelly beds succeeded by hard shales with jet, from very bituminous soft shales. 2. *Marlstone.* Alternating brown clays, and nasty ferruginous sands with occasional bands of limestone. Locally it consists of sands and shales. 3. *Lower Lias.* Dark laminated shales with occasional bands of limestone and concretions. 4. *White Lias.* White, sometimes micaceous sandstone or limestone (passing into the lias) by the lime bed. 5. *Variegated Marls.*	The lias accompanies the great oolitic band through the centre of England, from Lyme Regis northwards, after occupying considerable tracts of country. It is continued in Yorkshire, and bounds the oolitic tract there. Smaller tracts occur in Glamorganshire, and on the opposite side of the Severn, and an outlier in Shropshire, between Whitchurch and Market Drayton. In Scotland lias occurs at Brora, and in Skye, Eigg, and Mull. In Ireland, in Antrim.	The triassic beds form a broken ribband bordering the band of lias westwards, occupying a considerable transverse space in Derbyshire, and an isolated district in the lias in its centre in Shropshire and Cheshire. A smaller tract occurs in Cumberland.	This trias is much more developed on the Continent. There it consists of 1. "Muschelkalk," or "Muschelkalk." 2. "Keuper sandstone." Variegated sandstone marls. 2. "*Muschelkalk.*" A fossiliferous limestone. 3. "*Bunter Sand.*" Sixte, or "gres bigarré," a quartzose sandstone.	See Sir R. Murchison and Mr. Strickland on the New Red Sandstone, in the 5th vol. of Geological Transactions, 2d series. Professor Sedgwick, in the 4th vol. of the same. The Reptiles of our trias have been described by Owen in the Geological Transactions, and those of the Cambridge Philosophical Society.
	TRIAS, OR UPPER NEW RED SANDSTONE.	Red, blue, and green marls, and laminated clays, with fine salt and gypsum. 2. *Variegated Sandstone.* Variously coloured sandstone, with quartzose grits and conglomerate.			

PALÆOZOIC FORMATIONS.

PERMIAN.	Grey thin-bedded limestone, red marl, and gypsum. Earthy, occasionally hard and crystalline magnesian limestone, the lower part arenaceous and red. Conereliomary, and oolitic in places.	Extending through Nottinghamshire, Yorkshire, and Durham, as far as the mouth of the Tyne. Occupying a considerable area in Dumfries. Also in Cumberland, and Westmoreland.	The terms "Permian" has been given by Sir Roderick Murchison, to this, the highest section of the palæozoic series, on account of its great development in the district of Perm in Russia.	In Britain remains of Fish are found in the magnesian limestone. Reptiles (the *Thecodontosaurus*, and the *Palæosaurus*) have been found in the magnesian limestone of Bristol. Invertebrata, many of their remains distinctly linking the Permian beds with the other palæozoic formations, occur in the magnesian limestone of the north of England. Plants also occur allied to those of the coal measures. Reptiles occur in the Permian of Germany. Footsteps of birds are unknown, probably of the same age, in the United States.	Sedgwick Geological Transactions, 2d series, vol. iii. (for the Permian of the north of England). Murchison, Geology of Russia. Papers in the Geological Proceedings, by various authors.
	Dolomitic Conglomerate.	Fragments of mountain limestone, embedded in a red or yellow magnesian paste.	Near Bristol, and around the Mendips, occurring a considerable area in Glamorganshire?	In Germany the Permian series consists as follows:— A. Magnesian Limestone. { 4. Zechstein, { Letten, Stinkstein. 3. Rauwacke. 2. Argil. Schist. 1. Stinkstein. Kupferschiefer. Arenaceous Schist. B. Lower New Red Sandstone series. Roth-todte-liegendes.	
	B. Lower New Red Sandstone series.	Marls with thin bands of compact and shelly limestone. Lower new red sandstone (Rothe-todte-liegendes), quartzy grits, or fine-grained sandstone, coloured by oxide of iron. The fine sands and marls usually argillaceous. Conereliomary limestones in the lower beds in places.	Bordering the coal districts in Cumberland, Westmorland, Lancashire, Durham, Yorkshire, Cheshire, Shropshire, Staffordshire, Worcestershire, Nottinghamshire, and Warwickshire.	In France it is present in the north, and the formation is known as the "terrain penien," "terrain dolomitique," and "terrain pœcilomorphique." It is present in Spain, and on the northern bounds of Illyria. Permian rocks occur also in North America.	
	CARBONIFEROUS.	Seams of coal alternating with shales and sandstones, and in certain districts limestones. In Staffordshire this part of the series is capped by greenish grits and sandstones (considered a volcanic grit by Murchison). Lond shale, or pale fresh-water limestone (Ardwick limestone), in parts of Shropshire, Lancashire, and Warwickshire. The coal in England and Scotland is usually bituminous. In Ireland and South Wales anthracitic coals are extensively developed. The Burdiehouse fresh-water limestone of Scotland takes its place between the coal measures and the millstone grit.	Coal fields of England and Wales. 1. Durham and Newcastle. 2. Cumberland. 3. Yorkshire and Derbyshire. 4. Lancashire and Cheshire. 5. North Staffordshire. 6. Flintshire and Shropshire. 7. South Staffordshire. 8. Leicestershire. 9. Gloucestershire and Somersetshire. 10. Forest of Dean. 11. Glamorganshire and Monmouthshire. Great coal field of Scotland, in the counties of Ayrshire, Renfrewshire, Lanarkshire, Stirlingshire, Linlithgowshire, Haddingtonshire, Edinburghshire, Fifeshire, & neighboring small counties. The Irish coal fields are very small. They occur chiefly in Antrim, Tyrone, Kilkenny, and Tipperary.	The coal measures are rich in the remains of monocotyledonous plants and ferns, forming a peculiar and characteristic flora. *(See below on Mesp.)* Animal remains are comparatively scarce. The Burdiehouse and Glamorton beds have furnished some remarkable Fishes. *Megalichthys* and *Holoptychius* are characteristic genera. In the Ardwick fresh-water limestone, some remarkable remains of fresh-water animals occur. Remarkable Crustacea are found in some beds of this series, and remains of insects and Arachnida.	See the various memoirs and treatises on the British coal fields, and numerous papers in the Geological Society's Transactions, and proceedings in the Manchester Geological Transactions. The writings of Bald Mine and others on the Scottish coal fields. De la Beche in the 1st vol. of the Memoirs of the Geological Survey. Lindley and Hutton's Fossil Flora of Great Britain.
A. Coal-Measures.					

SECONDARY.

UPPER SECONDARY.	CRETACEOUS.	1. *Chalk with Flints.* Pure white carbonate of lime, containing horizontal bands of flint nodules. 2. *Chalk without Flints.* The same, but usually (not everywhere) free from flints. 3. *Chalk Marl.* Grey or yellow earthy or marly chalk, often indurated; sometimes green, from particles of silicate of iron (Dorset), or red (Norfolk and Yorkshire). 4. *Upper Green Sand.* Siliceous or calcareous sand, with green particles and nests; often hard (firestone). 5. *Gault.* Blue clay or marl, with nodules.	The several subdivisions of white chalk occupy a large expanse in the south-east of England, comprising considerable tracts in the counties of Suffolk, Cambridge, Herts, Buckingham, Oxford, Berks, Wilts, Hants, Dorset, Surrey, Kent, Lincoln, and Yorkshire. Out-lying patches occur in Devon. In Ireland chalk occurs in Antrim and Derry. The upper green sand forms the western boundary of the Lincoln and Yorkshire chalk; the northern and western of the chalk north of the Thames, running into Dorset. It here encircles the Weald, except on the sea-side, forms a considerable tract in the Isle of Wight, also in Devon, Dorset, and Somerset, where the Blackdown hills are famous for upper green sand fossils. It occurs in the cretaceous districts of the north of Ireland. The gault accompanies it in the east of England, where the lower green sand also is chiefly seen, especially in Surrey, Sussex, Kent, and the Isle of Wight.	The secondaries, and tertiaries, and alluvial stages of D'Orbigny, are equivalents of our lower green sand. So is the kilmaugloumerate of Germany.	1, 2, 3, Generally speaking, the fossils of the three upper stages of the chalk, which chalk indicate a deep-sea condition during its formation. The corals and Bryozoa peculiar to the chalk, and the Echinodermata, especially the Echinoidea, are characteristic. *Micraster, Ananchytes, Cidaris, Brissus*, and *Goniaster*) favour such conclusions. In the presence of numerous *Terebratulidæ*, *Inoceramus* and *Spondylus spinosus* are characteristic Conchifera, and among Cephalopoda *Marsupites* and among Cirrhopoda. *Several genera of Fishes (Beryx, Dercetis, Osmeroides, Pycnodus, Anenodon*). The *Lamellibranchiata* and *Brachiopoda* are frequent in the chalk marl, also *Serpulites spinifer*. *Ammonites varians, Mantelli*; peculiar *Nautili, (Gryphites columba* and *Sublamellata, Pecten asper, Plagiostoma spinosum* and *cardium, Cardium Hillanum.*) Sea urchins of the genera *Salenia* and *Cidaris*, *Spatangus* are peculiar forms. 4, *Hamites*, many species; *Ammonites varians, Beudanti, Nautili hexagonis* and *pertinatus, Inoceramus sulcatus.*	Conybeare and Phillips' Geology of England and Wales. The writings of Mantell. D'Orbigny, Paleontologie Française Terrain Cretacee. The works of Roemer, Goldfuss, Phillips, &c. &c.
	Upper Division.				
	Lower Division.	1. *Lower Green Sand.* Ferruginous sandstones and limestones (Kentish rag), with a bed of clay (Atherfield clay and fullers' earth). 2. *Weald Clay.* Blue and brown stiff clay, with beds of limestone (Sussex marble), sand, and clay-ironstone; all of fresh-water origin. 3. *Hastings Sand.* Variously coloured sands, sandstones and grits, the lower beds in places conglomerate. Clays and marls alternating with sands and shales at Tunbridge wells. All of fresh-water origin. 4. *Purbeck Beds.* Compact and fissile limestones alternating with clays, called fire-beds.	The chief development of the Wealden formation is in Kent and Sussex. It is present also in the Isle of Wight and the south of Dorsetshire, and in Wilts. Some tracts occur in Scotland, in Skye, Caithness, and Morayshire. Chiefly developed in the Isle of Purbeck.	Wealden beds, part of the same formation with those of the south of England, occur on the opposite coast of France, but so slightly developed, as to lead to the inference that they indicate the edge of the great fresh-water Wealden basin. In the north-west of Germany, Wealden beds are extensively developed. Asthe Wealden, in England, is a great fresh-water formation separating the cretaceous from the true oolitic strata, it is probable that its equivalents in other parts of the world will be found in marine strata, at the base of the cretaceous or newest of the oolite series.	The upper beds of the lower green sand are rarely fossiliferous. In the middle beds gigantic Scaphites, and *Ammonites, Astieri, Gerardus, cenomanensis, Beudanti, Terebratulæ* (especially *Terebratula sella*) occur at intervals. In the lower beds numerous Mollusca occur. *Ammonites Mantelli, Gerardus, cenomanensis* and *Inopinatus; Perna Mulleti, Pinnarca Filosa*, and *Gresslya Peregrina*, are characteristic. Peculiar Ammonites (some of them of the group Lyelli), *Ammonites Mantelli, Amphicoelus(Cristatus)* peculiar Belemnites, Conchifera approximate lower green sand species, and *Brachiopoda bearing sulcus* forms, characterize the Spatian clay, the true position of which is a matter of dispute. Our fish, the *Lepidotus minor*, is recorded. The Wealden strata contain numerous remains of plants. Many insects and fresh-water crustacea occur in the Purbeck beds. Numerous species of *Unio, Cyclas*, and *Paludina*, are the distinguishing characteristics. Fishes of the Pisces and Ganoid divisions, especially genera of the *Lepidoides, Lepidotus*. Reptiles of many genera, among which the *Iguanodon* is conspicuous. In the limestone of the Weald clay, *Paludinæ* are the most abundant fossils. In the Hastings sand, the greater number of the terrestrial remains of the Wealden occur. The limestones of the Purbeck beds abound in *Cyclades* and *Paludinæ*.	Fitton, *at supra*; Austen, Ibbetson, and E. Forbes, in Proceedings of Geological Society, and in the Geological Journal. The writings of Mantell. D'Orbigny, Paleontologie Française Terrain Cretacee. The works of Roemer, Goldfuss, Phillips, &c. &c. In the Brora, in the 21 vol. of the Geological Transactions. Fitton, on the Strata below the Chalk; in the 4th vol. of 2d series of Geological Transactions. De la Beche, in the 2d vol. of the Geological Proceedings.
	WEALDEN.				
		* *Sussex Clay.* Dark-blue laminated clay, with nodules of clay ironstone. This is probably its true position.	At Speeton, near Scarborough, Yorkshire.	The secondaries, and perhaps soften stages of D'Orbigny, are equivalents of our lower green sand. So is the kilmaugloumerate of Germany.	Fitton, *at supra*; Austen, Ibbetson, and E. Forbes, in Proceedings of Geological Society, and in the Geological Journal. The writings of Dubois de Montpertuex, Roemer, D'Orbigny, and Leymerie.
					Phillips' Geology of Yorkshire, pt. 1.
	UPPER OOLITES.	1. *Portland Stone.* a. Coarse earthy limestone (kimmeridge coal), with seams and nests of lignite, in the state of highly bituminous shale. (Kimmeridge coal.) 2. *Kimmeridge.* Blue or yellowish-grey laminated clays, with greenish and white beds of limestone, in the state of highly bituminous shale. (Kimmeridge coal.) 3. Greenish Silicious sand. (Portland sand.)	The upper oolites occupy small tracts in Dorsetshire, Wilts, and the Vale of Pickering, in Yorkshire.	In Normandy the lithographic limestone of Bleagny, and the clays of Honfleur, are representatives of our upper oolites. Also along the coast of France. Limestones and siliceous marls of this age occur in the Jura. In Germany the lithographic beds are about this parallel. In the south of Russia these oolite beds equivalents in time, and in India.	Plants of the genus *Zamites*, (*Z. megalophyllus* and *microphyllus*) are common in the Portland beds. Fossil Coniferæ occur in this formation. Reptiles of the genus *Cheloria* occur. The genus *Pliosaurus* is confined to the Kimmeridge. So is the *Steneosaurus*. Other large Saurians occur in the same formation. The Mollusca of the upper oolites are mostly Cephalopoda and Conchifera. Very few Acephalous Mollusca occur. Several Ammonites are peculiar to these beds. *A. rotundus, A. pleurospinus, A. impressus, A. Lamberti, A. zigzagoides, A. successor, A. biplex*, and *A. Brodiæi.*) Other Mollusca, and some other species, *Gryphæa virgula* and *nana, Perna quadrata* are characteristic fossils.	Phillips' Geology of Yorkshire. The papers of De la Beche, in the Geological Transactions, and Memoirs of the Geological Survey. Buckman and Strickland's edition of Macculloch's Geology of Cheltenham. Buckland's Bridgewater Treatise. Williamson, in Geological Transactions, 2d series, vols. v. and vi. Murchison on the Brora coal field, in the 2d vol. of the Geological Transactions, 2d series. D'Orbigny Paleontologie Française, Terrains Jurassiques, Goldfuss' Fossils of Germany, and Roemer's Works.
LOWER SECONDARY.	MIDDLE OOLITES.	1. *Coral Rag, and Calcareous Grits.* Sandy limestones filled with corals, covered by and found upon sandy beds, more or less mixed with calcareous matter, sometimes forming strata of marly rock. 2. *Oxford Clay.* Stiff blue clay, at times shaly, pyritiferous, and containing septaria, based in places on calcareous sandstone, or sandy limestone filled with organic remains (Kelloway's rock.)	The coral rag is chiefly developed in Wiltshire, Berks, and Oxfordshire. Also in Yorkshire, near Pickering and Malton. The calcareous grit occurs at Brora. The Oxford clay forms a nearly continuous tilland-like tract, winding through the midland and eastern counties of England, from Dorset to beyond the Humber, and again occurring in the oolitic tract of Yorkshire.	The Oxford clay and coral rag are present in the oolitic districts of France. The Normans limestone of the Jura appears to be the equivalent of the coral rag. *Equivalent beds* also occur in Germany and in the south of Russia. "Argile de divuet" is the Norman representative of the Oxford clay. The "etage corallien," and "etage Oxfordien," of the calcaire Jurassique, represent, in the Nomenclature of D'Orbigny, our middle oolites. Their German appellations are Korallen-kalk, and Oxford-ton.	Numerous organic remains occur in the coral rag, especially of species are recorded. The number of Mollusca is also very great (above 60 species are recorded). Gasteropoda are numerous. Of the echinoderms grits the number of species is very much smaller. The coral rag appears to have been a true coral reef. *Gervus gregarius* is a characteristic bivalve. The Oxford clay is rich in the remains of Cephalopoda, and is remarkable for containing in some of its beds entire fishes, preserved almost entire. Not more than 40 fossil Mollusca are recorded from the British beds of this formation. Radiata are very scarce in it. The Kelloway rock is rich in mollusca remains. Nearly 40 species are recorded, of which one-third are Cephalopoda. *Ammonites Brightii, Conybeari, Sulpicianus, Elizabethæ*, are well-marked Oxford clay *Ammonites*. *A. Calloviensis, Frearsii* and *Gowerianus* of the Kelloway rock.	See papers by Pratt and Morris, in the Annals of Natural History; and by Owen, in the Philosophical Transactions.

Many living species of Pteropoda are unprovided with shells. Numerous similar forms might have existed at former periods in the earth's history, and yet have left not a trace to bear witness of their ancient being.

GASTEROPODA.

The Gasteropoda of the British Silurians are comparatively few, and often very obscure. Many of them have been referred to existing genera, though with great uncertainty. *Natica*, *Capulus* (*Acroculia* of Phillips), and *Chiton* (*Helmetheochiton Griffithii* of Salter), are almost all the Silurian genera which appear truly of the same types with existing assemblages of species. The names *Littorina*, *Nerita*, *Patella*, *Trochus*, *Turbo*, and *Turritella*, have been applied to Silurian fossils respecting the true position of which there is reason to entertain many doubts. The genus *Loxonema* seems synonymous with, or, at any rate, closely allied to, the modern *Chemnitzia*. *Macrocheilus* seems to have been a true and peculiar paleozoic type. Under the heads of *Murchisonia*, *Pleurotomaria*, and *Euomphalus*, Mollusca of more orders than one have probably been included.

The same remarks apply to the reputed Gasteropods of the Devonian formation, where we find also fossils which have been referred, but with equal doubt, to the existing genera *Eucyclus* and *Murex*. The *Loxonema* group of *Chemnitzia* is greatly developed in this part of the geological series, as also in the carboniferous rocks. In the latter, *Pleurotomaria* and *Euomphalus* play an important part. The British carboniferous shells which have been referred to *Umbella*, *Trochelia*, *Terebra*, *Siphonaria*, *Loxonema*, *Bellerophon*, and *Fusispella*, are of very doubtful generic relations. The number of reputed British Gasteropods of the carboniferous epoch far exceeds that of previous formations.

In oolitic rocks we find numerous well-marked Gasteropods. There can be little doubt here of the true relationship of the *Trochi*. *Turbines*, *Rissoæ*, *Ritanellæ*, *Rostellariæ*, *Naticæ*, *Turritellæ*, *Chemnitziæ*, *Bullæ*, *Dentaliæ*, *Turnatellæ*, and *Emarginulæ*, with their existing genera which bear those names. The preservation of the shallow-water marine oolitic deposits has enabled us to judge very fairly of the extent of the oolitic Gasteropodous fauna. During this epoch the genus *Nerinea*, very characteristic of the time, appeared. *Pleurotomariæ* were very abundant.

In the Wealden fresh-water strata we find members of the genera *Melanopsis*, *Neritina*, and *Paludina*, many of them nearly allied to existing forms. In many parts of the cretaceous group many Gasteropods occur, without doubt members of existing genera. Here we have the final appearance of *Nerineæ*. The London clay Gasteropods are still more numerous, and more nearly allied to existing forms, but not identical. The genera *Bulla*, *Cerithium*, *Conus*, *Fusus*, *Natica*, *Murex*, *Pleurotoma*, *Solarium*, and above all, *Voluta*, had a great development within our area during the eocene period, and were associated with representatives of many other genera, the existing species of which are tropical, or subtropical. In the coralline crag the existing species of the British seas begin to appear, but very scantily. The number, however, increases rapidly in the red crag, and all, or almost all, that are found in the pleistocene beds are existing species of the North Atlantic.

Many Gasteropods occur in the fresh-water beds of the tertiary epochs. Thus in the Isle of Wight fresh-water eocene strata, we find no fewer than six species of *Limnæa*, six of *Melania*, as many of *Melanopsis* and *Planorbis*, and several *Paludinæ* and *Neritinæ*. In the fresh-water upper tertiaries most of the species are existing British forms; but there are also some apparently extinct, as the *Valvata antiqua*.

Abroad the paleozoic strata do not present many important generic additions to those enumerated in the British list. The Continental oolites also present a similar assemblage of Gasteropodous genera with that which characterizes our British beds of the same age. In France the cretaceous rocks present more numerous and varied Gasteropods than the English; and the cretaceous deposits of Southern India, which appear to have been formed in a moderate depth of water, abound in Gasteropods, associated generically very nearly as they are in tropical seas at present. Tertiary strata of all ages, and in all parts of the world, furnish numerous genera and species of this order of Molluscs, mostly related to existing types.

TABLE SHOWING THE DISTRIBUTION IN TIME OF THE PRINCIPAL GENERA OF GASTEROPODA.

Mollusca Gasteropoda.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Pleistocene.	Habitat of the Genus.
PULMONIFERA.								
Limax,						*	**	Terrestrial.
Helix,						*	***	Do.
Bulimus,						*	***	Do.
Pupa,						*	***	Do.
Clausilia,						*	***	Do.
Limnæus,						*	**	Inhabits fresh water.
Physa,						*	**	Do.
Planorbis,						*	**	Do.
Ancylus,						*	**	Do.
Auricula,						*	*	Brackish water, and margin of the sea.
PECTINIBRANCHIATA.								
Bulla,						*	*	Marine; various depths on sand and mud.
Bullæa,						*	**	On muddy ground in sea; and swimming.
Aplysia,						*	**	Do. usually in shallows.
Tornatella,						*	*	On sand in sea; shallow and deep.
Natica,			*	*	*	*	**	On sand and among gravel in sea; various depths.
Sigaretus,						*	*	Do.
Velutina,						*	*	Shallows, and moderate depths.
Marseulia,						*	*	Usually under deep water.
Ancillaria,						*	*	Shallows, and moderate depths.
Paludina,						*	*	
Valvata,						*	*	Fresh water.
Cyclostoma,						*	**	Do.
Littorina,						*	**	Terrestrial.
Littorina,						*	**	On rocks, &c., above low-water mark.
Rissoa,						*	**	On wrack in open ocean.
Melanopsis,						*	*	Littoral.
Melania,						*	**	On weed chiefly in shallow seas, but ranging deep.
Turritella,			*	*	*	*	**	Fresh water; usually of warm climates.
Scalaria,						*	*	Do. do.
Aloaria,						*	**	Marine; sublittoral, and ranging deep; mud.
Chemnitzia,			*	*	*	*	**	Marine; various depths; usually mud.
Eulimella,						*	*	Marine; moderate depths.
Odostomia,						*	*	Shallows, in very deep water.
Nerinea,			*	*				Do.
Pyramidella,						*	*	Do.
Scalina,						*	*	Do.
Eulima,						*	*	?
Mesalia,						*	*	Shallows.
Ringicula,						*	*	Various depths.
Ervilia,						*	*	Shallows, and considerable depths.
Vedovia,						*	*	?
Marginella,						*	*	Shallows.
Cypræa,						*	*	Various depths.
Ovula,						*	*	Shallows.
Oliva,						*	*	
Ancillaria,						*	*	Mostly littoral, or sublittoral, and tropical.
Terebellum,						*	*	Do.
Conus,						*	**	Do.
Voluta,						*	***	Do.
Mitra,						*	**	Do.
Columbella,						*	*	Do.
Strombus,						*	***	Do.
Pterocera,						*	**	Do.
Rostellaria,						*	**	Do. Ranges deep.
Pterodonta,						*	*	Do.
Struthiolaria,						*	*	Do.
Murex,						*	**	Do.
Ranella,						*	*	Do. Northern species in deep sea.
Triton,						*	*	?
Fusus,						*	*	Moderate depths?
Pyrula,						*	**	Shallows, and moderate depths.
Fasciolaria,						*	**	Shallows.
Pleurotoma,						*	**	Do. Rocky places.
Turbinella,						*	**	Various depths; some very deep-sea forms.
Cancellaria,						*	**	Shallows.
Cassidaria,						*	*	Do. Rocky places.
Cassis,						*	**	Various depths from 0 to very deep sea.
Harpa,						*	*	Shallows and moderate depths.
Dolium,						*	*	Moderate depths.
Trichotropis,						*	*	Shallows?
Buccinum,						*	*	Shallows and moderate depths.
Nassa,						*	*	Do. do.
Purpura,						*	*	Do. do.
Terebra,						*	*	?
Cerithium,						*	***	Mostly deep sea and northern.
						*	***	Various depths; genus not rightly bounded.
Murchisonia,						*	**	Mostly littoral and sublittoral.
						*	**	Littoral, on rocks.
Pleurotomaria,						*	**	Littoral, and moderate depths.
						*	***	? Mostly littoral and sublittoral, but ranging very deep.
Scissurella,						*	*	Marine.
Cirrus,						*	*	?
Haliotis,						*	*	Littoral.
Stomatia,						*	*	Moderate depths.
Nerita,						*	*	Littoral and sublittoral.
Phorus,						*	*	Littoral.
Trochus,						*	*	Moderate depths.
Rotella,						*	*	Littoral and sublittoral.
Solarium,						*	*	Moderate depths.
Delphinula,						*	*	Marine; various depths; the majority littoral.
Turbo,						*	*	Littoral.
Phasianella,						*	*	Littoral, and sublittoral.
Meglina,						*	*	Do. do.
Vermetus,						*	*	Littoral, and ranging to great depths.
Cæcum,						*	*	Littoral, and sublittoral.
Siliquaria,						*	*	In corals.
Emarginula,						*	*	Chiefly in rocks, and littoral.
Rimula,						*	*	Various depths.
Parmophorus,						*	*	Deep water.
Fissurella,						*	*	Marine; shallow water to great depths.
Siphonaria,						*	*	Do.
Lottia,						*	*	Littoral; on rocks.
Capulus,						*	*	Littoral, and ranging deep.
Calyptræa,						*	*	Littoral, on rocks.
Infundibulum,						*	*	Littoral, and ranging to deep sea.
Crepidula,						*	*	Marine; moderate deep sea.
Dentalium,						*	*	Marine; sublittoral.
								Do.
CYCLOBRANCHIATA.								Marine; littoral.
Patella,						*	*	Ranges to great depths in sand and mud.
Chiton,						*	***	Mostly littoral.
								Most littoral, but ranging deep in sea.

CONCHIFERA—LAMELLIBRANCHIATA.

Lamellibranchiate Bivalves are comparatively very scarce in the paleozoic rocks of Britain. In the lower Silurians they are especially rare; in the upper, but few. Such as do occur, though presenting forms which enable us with probability to pronounce on their relationship with existing genera, are still not in a condition to place that relationship beyond a doubt. Thus, though the Silurian shells referred to *Arca*, *Nucula*, and *Pectunculus* appear beyond question to be Arcaceæ, they present peculiarities of form and structure which would rather indicate that they are specific types, linking those genera with each other, than true members of them. The group of shells referred to *Cypricardia*, very characteristic of certain upper Silurian strata, appears to have no true relationship with that genus, but rather to have been members of the family *Mytilacea*, and allies of Modiola. The so-called *Pullastræ* are of like nature, and the Silurian shells called *Sanguinolariæ* and *Sanguinolitæ*; under which latter name, indeed, all might be conveniently united. The various extinct genera *Pleurorhynchus* and *Cardiola* are more certain. Numerous species of *Arcicula* and allied shells, known as *Isocardiæ*, *Pseudocardiæ*, and *Pleuronectæ*, constitute the Silurian Monomyarian, and some of those of the first named genus present a striking analogy with forms of *Arcicula* now living.

In the Devonian rocks, the general assemblage of Conchifera is similar to that in the Silurians, and the same remarks apply. The genus *Pleurorhynchus* increases. The extinct genus *Megalodon* occurs. Well-formed *Pectenes* appear, and are numerous in species (eight).

The number of Lamellibranchiata is greatly increased in the carboniferous limestones, especially those of Ireland. (See M'Coy's Synopsis.) These have been referred to numerous genera, many of them existing, but not always on reasonable grounds. Thus, the genera *Amphidesma*, *Anatina*, *Cardiola*, *Lutraria*, *Mactra*, *Mytilus*, *Nucula*, *Cremella*, *Pandora*, *Pneumodesma*, *Artemis*, *Venerupis*, *Pullastra*, *Ungulina*, *Cyprina*, *Anomia*, *Melagrina*, *Lithodomus*, *Corbis*, and *Donax*, are enumerated in British lists of carboniferous limestone fossils, though the evidence we have at present is quite insufficient to permit of our regarding those genera as palæozoic, and the numerous fossils which have been referred to them might with equal probability be referred to as many genera of other orders. Many of the new genera, such as *Leptodomus*, *Dolabra*, and *Sedgwickia*, are also very indistinct. It may, however, be said generally of the carboniferous Lamellibranchiata, that they present a marked advance towards existing forms. This is especially seen among the *Acæcea*. We know too little yet of Permian and triassic Lamellibranchiata to pronounce definitely on their generic relations. During the oolitic period, numerous well-marked genera appeared for the first time, many of them still existing, others extinct. The oolitic *Arcacea* have very definite relations with existing forms; so have the species of *Carbula*, *Pinna*, the *Mytilacea*, many of the *Venea* tribe, *Astarte*, *Lucina*, and *Crenatula*. The genera most developed in British strata, are *Pholadomya*, of which 19 species are enumerated, *Mulsula* (17), *Area* (23), *Nucula* (11), *Trigonia* (13), *Astarte* (22), *Cardinia* (12), *Cardium* (12), *Isocardia* (11), *Pecten* (21), *Lima* (25), *Gervillia* (10), and *Ostrea*, including *Gryphæa* (33). Some genera, of which there are few species, are also highly characteristic, as *Perna* (2), *Pholas* (2), *Panopæa* (several), *Opis* (2), *Myoconcha* (1), *Lyonsæna* (4), *Hippopodium* (1), and *Corbis* (3). In the fresh-water beds of the Wealden, numerous well-marked species of *Unio* occur with *Cyclas* and *Dreissena*. The British cretaceous *Lamellibranchiata* have considerable relations with oolitic forms, and in some few instances (as *Gervillia arieulaloides*) appear to be identical. The greater number occur in the green sands, and indicate the formation of those beds (whether upper or lower) to have been in shallower water than that in which the chalk was deposited. The genera greatly developed are *Area* (12), *Nucula* (11), *Trigonia* (12), *Venus* (17), *Inoceramus* (17), *Ostrea* with *Gryphæa* (20), *Lima* (12), and *Pecten* (14). The presence of true species of *Crenatulla*, *Cyprina*, *Cardita*, *Solen*, and *Spondylus* is worthy of note. *Pholadomya*, *Panopæa*, *Corbis*, *Corbula*, *Isocardia*, *Anomia*, *Arcicula*, *Gervillia*, *Pinnula*, and *Perna*, have well-marked representatives among British cretaceous fossils. *Thetis* is a remarkable genus of this period.

The British eocene Bivalves have been carefully investigated by Mr. Edwards, and are of great interest, on account of the light they throw upon the climate of our area at the commencement of the tertiary period: So far as the most recently published lists afford information, the following is the state of this part of our eocene fauna:—

PHOLADIDÆ.—*Teredo* 2, *Pholas* 2, *Gastrochæna* 1, *Fistulana* 1, *Clavagella* 1, *Saxicava*, 1, *Petricola* 1.

CORBULIDÆ.—*Corbula* 13, *Neæra* 4, *Potamomya* 2.

MYADÆ.—*Mya* 1, *Panopæa* 2, *Pholadomya* 1.

AMATHUSIDÆ.—*Tervecia* 2.

SOLENIDÆ.—*Solen* 4.

SOLENOCURTIDÆ.—*Solenocurtus* 1, *Glycimeris* 1.

TELLINIDÆ.—*Tellina* 21, *Mesodesma* 1, *Amphidesma* 1, *Psammobia* 3.

MACTRADÆ.—*Mactra* 4.

VENERIDÆ.—*Venus* 18, *Diplodonta* 1.

CYPRINIDÆ.—*Cyprina* 2, *Astarte* 4, *Cardita* 8.

CARDIADÆ.—*Cardium* 10, *Cardita* 1, *Cypricardia* 3.

CYCLADIDÆ.—*Cyrena* 6.

LUCINIDÆ.—*Lucina* 16, *Corbis* 1.

KELLIADÆ.—*Kellia* 2, *Lepton* 1.

CHAMADÆ.—*Chama* 3, *Isocardia* 1.

ARCACEÆ.—*Arca* 6, *Nucula* 12, *Pectunculus* 5.

MYTILACEÆ.—*Mytilus* 7, *Dreissena* 1, *Perna* 3.

AVICULACEÆ.—*Avicula* 3.

PECTINIDÆ.—*Pecten* 3, *Lima* 1.

OSTREADÆ.—*Ostrea* 9, *Vulsella* 1.

None of the above is an existing British species.

In our upper tertiaries a considerable number of Lamellibranchiata occur. The majority of these are existing forms, which, numerous in our miocene beds, become still more numerous in the pliocene, and in the pleistocene the Conchifera are all, with two or three exceptions, identical with living species. The general character of the miocene Bivalves is Mediterranean, or rather Lusitanian: that of the pleiocene, mixed Mediterranean and northern: that of the pleistocene essentially boreal and arctic. In the last named formation several of the species are extinct in the British seas now, but still live in the arctic seas, or on the coasts of Boreal America. Of the forms altogether extinct, one very remarkable species of *Nucula* (the *Nucula Cobboldiæ*) appears to have been destroyed in consequence of the upheaval of the bed of the pleistocene German Ocean.

Several generic forms of *Lamellibranchiata* occur in foreign strata, of various ages, which are unrepresented in the rocks of Britain.

BRACHIOPODA.

The Palliobranchiate Mollusca play a very important part in the faunas of the several geological formations, especially of the older rocks. They seem anciently to have attained a development far exceeding that which the order now presents, and many generic types or subordinate groups have entirely disappeared. Such types are very important to the palæontologist, since they hold very definite relations to epochs in time, and consequently afford great assistance in the determination of the ages of rocks.

Brachiopoda were the earliest of animals in their appearance in time. Species of *Lingula*, a genus still existing, appear to have been the most ancient of Silurian animals. Other genera rapidly succeed, and the number of species found fossil in the upper and lower Silurians is very great. Considerably above 100 kinds are known in the British Silurians. Of these, the various forms of *Orthis* are among the most remarkable. About 50 British Silurian species of this genus are known. The genus *Leptæna*, of which we have about 20 British forms, is also very characteristic. *Pentamerus*, including but few species, is peculiarly Silurian. Not a few well-marked *Spirifers* are also found in these rocks, and between 40 and 50 of their fossils are recorded as species of *Terebratula* and *Atrypa*. Several well-marked species of Orthicula are of this age, and one *Crania*; also two or three species of *Productus*.

In the Devonian rocks, the number of species of *Spirifer* greatly increases. Between 30 and 40, thrice as many as there are in the Silurians, have been found. The genus *Strigocephalus* replaces *Pentamerus*. *Productí* double their number. *Orthides* greatly decrease. *Leptænæ* (and *Chonetes*) continue. *Terebratulæ* and *Atrypæ* have numerous representatives. *Calceola* is peculiarly Devonian.

In our carboniferous limestones the *Spiriferæ* double their number, and the smooth section of this genus (*Martinia* of M'Coy) becomes highly developed and characteristic. *Productus* attains its maximum, and includes between 40 and 50 British forms. *Orthides* are as numerous as in the Devonian. *Leptænæ* have greatly decreased; but *Chonetes* attains its maximum. *Terebratulæ* are numerous as *Lingulæ*, and *Orbiculæ*, have their representatives.

In the Permian the few forms of Brachiopods recorded are closely allied to the carboniferous, especially the species of Productus.

No Brachiopods have been found in our triassic strata.

In the oolites, a great change has taken place among this order of Mollusca, as compared with its paleozoic development. True *Terebratulæ* now prevail (between 40 and 50 recorded). Most of the characteristic paleozoic genera have disappeared, except *Spirifer*, of which we have five oolitic representatives. *Lingulæ*, *Orbiculæ*, and *Discinæ*, are all present.

The cretaceous Brachiopods are mostly species of *Terebratula* (about 40 are recorded). Among these is a form, *Terebratula striatula*, not to be distinguished from the existing *Terebratula caput serpentis*. The other genera are *Magas*, *Lingula*, *Crania* (which attains a considerable development in the chalk) and *Orbiculæ*. In the cretaceous rocks we find the anomalous *Radiatæ*, of which, however, we have only three forms in Britain.

The Brachiopods of our eocene beds are very few; *Lingula* (toxoic) and *Terebratula striatula* are the chief forms. In the upper tertiaries there is a *Lingula* in the coralline crag, wherein also occurs the existing *Crania Norvegica*. *Terebratula striatula* is a large extinct red crag species; and *Terebratula pelitacea*, identical with the existing form, occurs in the pleistocene and mammaliferous crag. Another species *Terebratula cistellula*, occurs in the crag, and has been very recently dredged alive on the coasts of Scotland.

Among foreign fossil Brachiopods the genera *Siphonotreta* and *Obolus*, both paleozoic, have no British representatives.

TABLE SHOWING THE DISTRIBUTION IN TIME OF THE PRINCIPAL GENERA OF MOLLUSCA ACEPHALA.

Mollusca Acephala.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Pleistocene.	Habitat of the Genus.
LAMELLIBRANCHIATA.								
Teredo,					*	*	*	Marine; borer in floating wood.
Pholas,					*	*	*	Marine; borer in rocks, clay, and wood.
Aspergillum,					*	*	*	Marine; burrows in sand; sub-littoral.
Clavagella,					*	*	*	Marine; burrows in rocks, &c., to some depth.
Gastrochæna,					*	*	*	Do. do.
Saxicava,					*	*	*	Do. do., and free.
Petricola,					*	*	*	Shallows, and moderate depths; boring.
Venerupis,					*	*	*	Do. do.
Pholadomya,	*	*	*	*	*	*		Moderately deep water?
Panopæa,	*	*	*	*	*	*	*	Shallows.
Mya,					*	*	*	Shallows, littoral, and moderate depths.
Lutraria,					*	*	**	Do. do.
Glycimeris,					*	*	**	Do. do.

The British eocene species have been recently *carefully* worked by Agassiz. *(See table on map for general results.)* Among the Pleurotomidæ, the genus *Mitrolumbus* is most developed. Among the Gastropoda, *Pugnellus*; the twelve eocene Clausilidæ belong to eleven genera, and the Cyclostoma are nearly as numerous as to genera as species, of which there are between thirty and forty.

Our knowledge of the Fishes of the epoch of our upper tertiaries is as yet very imperfect. The *Zeuglodon Woodwardii*, the *Ruia antipus*, and the *Platax Woodwardii*, are the principal recorded forms. In fresh-water beds of the pleistocene epoch, remains of the pike, *Esox lucius*, have been found. It is the only British fossil Fish identical with our existing species.

Abroad, numerous old red sandstone Fishes occur in Russia, where also the Permian species have chiefly been observed. The muschelkalk beds of St. Cassian, in the Tyrol, furnish numerous Fishes, supposed to be of triassic age. Numerous oolitic and cretaceous Fishes have been found on the Continent. Of the latter age are the famous slates of Glaris, which have all the aspect of ancient rocks, but abound in organic remains evidently cretaceous. About forty species of fossil Fishes have been found in that locality. With the exception of the eocene, foreign tertiaries are much richer in Ichthyic remains than those of the British Isles. The miocene and pliocene formations of Southern Europe and Western Asia are rich in such remains. From them, and from deposits in Germany, species of thirty-seven genera are recorded. In the Indian newer tertiaries, numerous fresh-water Fishes have been found, related generically to existing forms of the region. In the pleistocene beds of North America the Capelan, *Mallotus villosus*, is found in a fossil state.

For the study of fossil Fishes the works of Professor Agassiz should be consulted. The finest collections are those of the Earl of Enniskillen and of Sir Philip Grey Egerton. The following table exhibits the names and distribution of described genera:—

MILLERIAN.	CARBONIFEROUS.	PERMIAN.	OOLITIC.	CRETACEOUS.	UPPER TERTIARY.	NEWER TERTIARY.
Onchus.	Amblypterus.	Amblypterus.	Coccolepis.	Beryx.	Labrax.	Perca.
	Palæoniscus.	Palæoniscus.	Tetragonolepis.	Lates.	Smerdis.	Smerdis.
	Platysomus.	Platysomus.	Dapedius.	Sphenocephalus.	Smerdis.	Cottus.
	Eurynotus.	Pygopterus.	Amblypterus.	Acrogaster.	Dentex.	Pristis.
	Diplurus.	Acrolepis.	Semionotus.	Acanthus.	Sargus.	Mallotus.
DEVONIAN.	Diplopterus.	Cœlacanthus.	Lepidotus.	Pedicia.	Cottus.	Silurus.
	Acanthodes.	Acrolus.	Pholidophorus.	Fistularia.	Holocanthus.	Lebrias.
Pterichthys.	Pygopterus.	Dictus.	Notacanthus.	Echeneis.	Macrorhinus.	Sciæna.
Pamphractus.	Acrolepis.	Dictus.	Ophiopsis.	Tetrapturus.	Cybium.	Cyclurus.
Homothorax.	Megalichthys.	Gyropristis.	Notagaus.	Hypsodon.	Gasterosteus.	Leuciscus.
Phaneropleuron.	Graphiolepis.		Pygopterus.	Saurocephalus.	Hemiramphus.	Esox.
Polyplocterus.	Podolepis.		Lepidolepis.	Saurodon.	Tetrapturus.	Rhodeus.
Cheiopterygius.	Gyrolepis.	THRASSIC.	Amblypterus.	Clidastes.	Galeocerdo.	Cobitis.
Coccosteus.	Cœlacanthus.		Belonostomus.	Istiurus.	Sphyrænodus.	Acanthopsis.
Cephalaspis.	Hoplopygus.	Amblypterus.	Caturus.	Osmeroides.	Hyperodon.	Lebias.
Acanthodes.	Uronemus.	Gyrolepis.	Pachycormus.	Osmeroides.	Sphænolepis.	Esox.
Diplacanthus.	Holoptychius.	Saurichthys.	Sauropsis.	Acrogaster.	Ergalepis.	Sphenolepis.
Cheiracanthus.	Phyllolepis.	Saurichthys.	Eugnathus.	Anhelepis.	Notacus.	Clupea.
Cheiracanthus.	Cœlacanthus.	Cœlacanthus.	Caturus.	Lebias.	Lycoptera.	Anguilla.
Diplurus.	Chalcides.	Pycnodus.	Pycnodus.	Amblypterus.	Pycnodus.	Pycodus.
Osteolepis.	Diplodus.	Spharodus.	Thrissolepis.	Anenchelum.	Pycnodus.	Blochius.
Diplopterus.	Orodus.	Placodus.	Amblysemius.	Notocopterus.	Dyrodus.	Ischyodus.
Glyptopomus.	Cœnoptychius.	Dolerodus.	Megalurus.	Polypriones.	Dyrodus.	Edaphodon.
Megalichthys.	Chomatodus.	Hybodus.	Dapedius.	Acrolepis.	Phyllodus.	Edaphodon.
Glyptolepis.	Psammodus.	Xiphodus.	Thrissops.	Ctenoides.	Glyptocephalus.	Pamphodon.
Phyllolepis.	Helodus.	Acrodus.	Thrissus.	Lepidotus.	Acripenser.	Carcharodon.
Holoptychius.	Cochlodus.	Cyrtodus.	Cyrtolepis.	Pleuropholis.	Elasmodus.	Sphyrna.
Asthenolepis.	Cteniodus.	Cladodus.	Cimolopis.	Palæobalistum.	Palæobalistum.	Corax.
Platygnathus.	Psephodus.	Lebunotichus.	Undina.	Pleuropholis.	Edaphodon.	Galeocerdo.
Dendrodus.	Portlandus.		Sphærodus.	Lepidotus.	Glyphis.	Hemipristis.
Lamnodus.	Pleuracanthus.		Pycnodus.	Gonorhynchus.	Carcharodon.	Notidanus.
Glaucolus.			Gyrodus.	Caturus.	Notidanus.	Otodus.
Asterolepis.			Gymnodus.	Macropoma.	Otodus.	Oxyrhina.
Bothriolepis.			Sphærodus.	Sphærodus.	Pycnodus.	Oxyrhina.
Pamphractus.			Strophodus.	Pycnodus.	Oxyrhina.	Lamna.
Homacanthus.			Ischyodus.	Sphærodus.	Lamna.	Hybodus.
Hoplacanthus.			Gualdo.	Gyrodus.	Lamna.	Pristis.
Odontacanthus.			Psilmodon.	Dercetis.	Scyllodus.	Pristis.
Saurodus.			Thrillius.	Acanthodesmus.	Scyllodus.	Rhinobatis.
Naulas.			Anthracosaurus.	Ischyodus.	Rhinobatis.	Zygobates.
Byssacanthus.			Lamna.	Psilmodon.	Pycnacanthus.	Myliobates.
Onchus.			Notidanus.	Carcharias.		Cyclobatis.
Pterichthyodes.			Ellipsis.	Corax.		
Cirracanthus.			Oxyrhina.	Galeocerdo.		
Climatius.			Hybodus.	Hemipristis.		
Parexus.			Sphenonchus.	Notidanus.		
Cosmacanthus.			Acrodus.	Otodus.		
Climodus.			Ceratodus.	Oxyrhina.		
Leptacanthus.			Leptacanthus.	Lamna.		
Cladodus.			Myriacanthus.	Scyllodus.		
			Anacanthus.	Thrillius.		
			Nemacanthus.	Hybodus.		
			Prionacanthus.	Strophodus.		
			Strophodus.	Acrodus.		
			Squatirhia.	Psychodus.		
			Cyclorhiza.			
			Acrodorsum.			
			Eurycirrhus.			

MOLLUSCA.

CEPHALOPODA.

In a geological point of view, the Mollusous division is probably that class of animals the fossil remains of which are most important in guiding us to conclusions respecting the age of sedimentary strata, and the conditions under which they were deposited. Generally speaking, the shells of Mollusca afford a certain clew to the nature and relation of the creatures which originally formed them. Their abundance, wide and marked diffusion, and the very perfect manner in which they are frequently preserved, render them valuable aids to the geologist.

The greater part of fossil Mollusca belongs to genera which are still represented among living animals. These genera, however, have very various ranges in time—some dating back to the epoch of the oldest sedimentary fossiliferous rocks, others, comparatively of very recent origin. Rarely do we find members of any genus preserved in formations widely apart, without there being allied forms of the same group in the intermediate formations. A few genera are confined to a single epoch—more range through several, but become extinct before the commencement of the present era. Such genera are usually of paleozoic origin, or have their maxima of development during the earliest geological ages. It would appear that the highest groups of shelled Mollusca were most developed, numerically, during the earlier epochs; so also were the Brachiopoda; whilst the Gasteropoda and Conchifera increased in numbers during the later periods, and as they approached the present. Our knowledge of the habits of existing Mollusca would lead us to the inference, that the cause of this phenomenon is to be sought in the destruction of the shallow-water deposits formed during the remoter epochs, and the preservation of strata of deep-sea origin. For, in the former, the Gasteropoda and Lamellibranchiata would be most likely to be preserved, and in the latter the Cephalopoda, Pteropoda, and Brachiopoda.

During the Silurian epoch many genera and species of Cephalopods inhabited the British seas.

The genus *Orthoceras*, the forms and size of whose species would lead us to infer that they were oceanic creatures, and inhabitants of deep seas, were especially abundant. Nearly forty Reidh Silurian Orthocerates are recorded, and there are many species in collections as yet unpublished. *Phragmoceras* and *Gomphoceras* were allied genera, very characteristic, also, of this epoch. Many forms of *Lituites*, and a few of *Nautilus*, accompanied them. In Devonian strata we find *Orthocerates* abundant, and the genera *Clymenia*, *Cyrtoceras*, and *Goniatites*, greatly developed. The last named genus becomes enormously developed, comparatively, in the carboniferous limestones, playing the part in the paleozoic epoch which Ammonites afterwards played in the secondary. At the same time *Nautili* were very abundant; and the genus presented many peculiar modifications, or sub-genera, characteristic of the time; whilst *Orthoceras* was also fully represented, the allied genus *Actinoceras*, appeared and disappeared. *Cyrtoceras* and *Phragmoceras* became almost extinct. Most of the genera above mentioned are peculiar to the paleozoic epoch as a whole, and eminently distinguish the sedimentary strata of that age from after-formations.

With the commencement of the secondary epoch, a new series of Cephalopods appeared in the seas of our area. The paleozoic genera, with the exception of *Nautilus*, had disappeared. We get in the lias the first remains of cuttle-fishes, resembling in general habits those which now live. The Belemnites appear and become very abundant, giving a well-marked character to secondary paleontology. Peculiar modifications of the genus *Hamites*, which have received the name *Ancyloceras* and *Crioceras*, commenced. Above all, the genus *Ammonites* came into existence, and rapidly attained an enormous development, far beyond that of any other group of Cephalopoda, whether fossil or recent. Peculiar forms of *Ammonites* distinguished the earlier from the later oolitic formations, and afford admirable clews for the identification of secondary strata far apart.

The Ammonites continued during the cretaceous epoch, and were very abundant till its close, when they finally disappeared. The genus *Hamites* attained a great development; and in Britain the species are chiefly to be found in the gault. *Scaphites* became a prominent and characteristic genus. *Belemnites* remained, but greatly diminished in numbers. *Turrilites*, *Baculites*, and *Ptychoceras* especially characterized the latter half of the secondary epoch. *Nautilus* assumed forms closely resembling those of the very few existing species.

In our eocene marine tertiaries the testaceous Cephalopods are reduced to a few species of *Nautilus*; one of which, the *Nautilus expansus*, is remarkable for its affinities with certain paleozoic forms. No Nautili have been found in any of the crag deposits; and we have reason to believe that after the eocene period, no testaceous Cephalopods ranged to our seas. It is likely, however, the cuttle-fishes of which we find eocene remains, were not uncommon during the miocene and pliocene epochs, and probably, also, during the pleistocene.

The arrangement of the Ammonites in natural groups, as proposed by Baron Von Buch, is so important in a geological point of view, as well as zoologically, that we introduce it here. The evidence it affords of modification of forms, even in a single genus, having reference to epochs in time, indicates a much more valuable principle for the determination of the relations of fossiliferous beds, geographically far apart and disconnected, than that of their identification by means of identical species. Identical species in distant beds far apart, rather indicate that such beds are not synchronic; for every species must have time given it for its diffusion.

The following is an outline of Von Buch's classification of Ammonites, as modified by Alcide D'Orbigny.[1] *(See figures of the types on the map.)*

A.—*Species with an entire dorsal keel.*

Group I. *Arietes.* (Von Buch.)—Sides of shell ornamented with simple radiating ribs. Back squared, and furnished with a median keel, in which the siphon is placed. Mouth beaked. Partition-sutures formed of unsymmetrical lobes and saddles. Dorsal lobe no deep as broad, and longer than the superior lateral. Dorsal saddle very short, the lateral one very long.

Species peculiar to the lias (lower beds).

Group II. *Falciferi.* (Von Buch.)—Shell compressed, the sides ornamented with bent folds, without tubercles. Back sharp and prominent, keeled. Dorsal saddle very long. Lateral lobe always much longer than the dorsal lobe. Saddles almost symmetrical.

Upper beds of the lias.

Group III. *Coritati.* (D'Orbigny.)—Shell compressed, ornamented with bifurcated bent ribs, which sometimes bear tubercles. Back prominent, keeled. Dorsal edge of the mouth prolonged into a beak, when the shell is full grown. Lobes and saddles usually symmetrically divided. The lateral lies elevated than the other saddles.

Cretaceous. In the lower green sand, gault, and upper green sand.

Species with the back channelled.

Group IV. *Tuberculati.* (D'Orbigny.)—Shell with lateral ribs and tubercles, which alternate on the two sides of the back. Back excavated centrally by a deep canal. Mouth complete, notched dorsally. Lobes and saddles divided unsymmetrically. Dorsal lobe shorter than the superior lateral, and as narrow as the dorsal canal.

Gault and upper green sand.

Species with the back sharp, but not keeled.

Group V. *Clypeiformi.* (D'Orbigny.)—Shell compressed, usually smooth, or slightly wrinkled at the sides. Back very sharp. The last whorl usually embracing all the others. Partition-sutures divided into numerous lobes unsymmetrically branched, and saddles symmetrically branched.

Neocomian, gault, and upper green sand.

Species with the back prominent and crenated.

Group VI. *Annulati.* (Von Buch.)—Shell ornamented on the sides with gentle arcuated ribs; the back sharp and transversely crenated. Mouth beaked dorsally. Lobes and saddles divided unsymmetrically. Dorsal lobe shorter than the superior lateral.

Oolites.

Group VII. *Rhotomagenses.* (D'Orbigny.)—Shell with inflated, squared, or oval whorls, ornamented with prominent ribs, which bear several ranges of tubercles, one row being on the sums of the back. Lobes and saddles symmetrically divided. Dorsal lobe longer than the superior lateral.

Gault and upper green sand.

Group VIII. *Pulchelli.* (D'Orbigny.)—Shell with prominent, straight ribs on two sides, passing over the back, on which they form a crest. Lobes symmetrical; saddles unsymmetrical. Dorsal lobe equal to the superior lateral.

Gault and lower green sand.

Species with the back excavated, and the sides tuberculated.

Group IX. *Dentati.* (Von Buch.)—Shell more or less inflated; ribbed at sides; ribs often bifurcated, and tuberculated round the umbilicus; their extremities prominent on each side of the hollowed-out back. Lobes divided unsymmetrically; saddles symmetrically.

Neocomian, or lower green sand, and gault.

Group X. *Ornati.* (Von Buch.)—Shell slightly inflated; back narrow, bordered with tubercles; another range of tubercles on the middle of the sides of the whorls. Lobes and saddles unsymmetrically divided. Dorsal lobe always very much shorter than the superior lateral.

All Oxford clay species.

Species with the back more or less squared.

Group XI. *Flexuosi.* (Von Buch.)—Sides of shell with a row of tubercles round the umbilicus, and another on each side of the back, the centre of which is slightly prominent. Lobes and saddles unsymmetrically divided. Dorsal lobe shorter than the superior lateral, which is very large.

All neocomian species.

Group XII. *Compressi.* (D'Orbigny.)—Shell generally much compressed with enveloping whorls, which are ribbed or striated on the side. The ribs or strie slightly arcuated, and forming tubercles on the sides of the back, which is narrow and truncated. Lobes unsymmetrically, saddles symmetrically divided. Dorsal lobe very large, much longer than the superior lateral.

Upper green sand.

Group XIII. *Armati.* (Von Buch.)—Shell with squared whorls, the back bordered on each edge by a range of tubercles; other ranges on the sides. Back broad. Lobes unsymmetrically, saddles symmetrically divided. Dorsal lobe longer, or equal to the superior lateral, which is placed on the middle of the sides of the whorl, and is always narrower than the dorsal saddle.

Upper beds of the oolites.

Group XIV. *Angulicostati.* (D'Orbigny.)—Shell thick, with nearly round whorls. Back narrower than the sides, which are ornamented with elevated ribs crossing the back. Lobes unsymmetrically, saddles usually symmetrically divided. Dorsal lobe shorter than the superior lateral.

Lower green sand and gault.

Group XV. *Capricorni.* (Von Buch.)—Shell with very convex whorls, ornamented with simple strait plain ribs. Back broad; wider than the sides. Lobes unsymmetrically, saddles symmetrically divided. Dorsal lobe longest.

Oolitic.

Species with the back rounded, convex.

Group XVI. *Heterophylli.* (D'Orbigny.)—Shell compressed, the whorls enveloping. Sides smooth, slightly striated or furrowed. Back very convex, and not very broad. Lobes much ramified, unsymmetrically divided: the saddles mostly symmetrically. Dorsal lobe almost always shorter than the superior lateral.

Those with unsymmetrical saddles are few, and are colitic (as A. heterophyllus); the others are from the lower part of the cretaceous system.[1]

Group XVII. *Ligati.* (D'Orbigny.)—Shell compressed, generally smooth, or slightly undulated, and marked at intervals with varices and channels. Back convex, sometimes slightly compressed. Lobes unsymmetrically divided; saddles usually symmetrical.

All cretaceous.

Group XVIII. *Planulati.* (Von Buch.)—Discoidal, whorls cylindrical, striated or closely ribbed partially. Lobes divided unsymmetrically; the saddles symmetrically. The auxiliary lobes very oblique, and turned towards the umbilicus.

Cretaceous; the lowest beds.

Group XIX. *Carousani.* (Von Buch.)—Distinguished from the Planulati by the presence of a tubercle at the point of bifurcation of the strie or ribs.

Lower oolitic strata.

Group XX. *Macrocephali.* (Von Buch.)—Like the Coronarii, but more inflated, and having the tubercles, instead of being placed mid-way on the side of the whorl, projecting near the umbilicus.

Jurassic and neocomian.

Group XXI. *Fimbriati.* (D'Orbigny.)—Discoidal; whorls cylindrical, contiguous and not enveloping, smooth, or with distant varices. Mouth circular. Lobes and saddles symmetrically divided; broad at the extremities, narrow at their bases.

Lias and lower green sand.

TABLE OF THE DISTRIBUTION IN TIME OF THE PRINCIPAL GENERA OF CEPHALOPODA.

Cephalopoda.	Lower Paleozoic.	Upper Paleozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present.
Sepia,	—	—	+	—	—	—	—
Sepiadenthis,	—	—	+	—	+	+	+
Onemidosepion,	—	—	+	—	—	—	—
Kalaeno,	—	—	+	—	—	—	—
Belopeltis,	—	—	+	—	—	—	—
Onychoteuthis,	—	—	+	—	—	—	—
Teudopsis,	—	—	+	—	—	—	—
Spirulirostra,	—	—	+	—	—	—	—
Belemnites,	—	—	++	+	—	—	—
Orthoceras	—	++	+	—	—	—	—
Actinoceras,	—	++	+	—	—	—	—
Cyrtoceras,	—	+	—	—	—	—	—
Phragmoceras,	—	++	+	—	—	—	—
Gomphoceras,	—	++	+	—	—	—	—
Cyrtocalx,	—	++	—	—	—	—	—
Lituites,	—	+	—	—	—	—	—
Nautilus,	—	++	++	—	+	+	+
Clymenia,	—	++	—	—	—	—	—
Goniatites,	—	++	—	—	—	—	—
Ammonites,	—	—	+++	++	—	—	—
Scaphites,	—	—	+	+	—	—	—
Turrilites,	—	—	+	+	—	—	—
Hamites,	—	—	+	+	—	—	—
Baculites,	—	—	+	+	—	—	—
Ptychoceras,	—	—	+	+	—	—	—

HETEROPODA.

The genus *Bellerophon*, confined to rocks of paleozoic age, and especially abundant in those of the Silurian system, is supposed to belong to this division of Mollusca. All existing Heteropoda are free swimmers, and are found chiefly in the open sea, especially where it is of great depth.

PTEROPODA.

This is also an order of pelagic and swimming Mollusca. They appear to have inhabited the earliest seas; for there can be little question that the paleozoic genus *Conularia* was a Pteropod nearly allied to *Cleodora*. Species of *Conularia* are found in Silurian, Devonian, and Carboniferous strata. In Silurian rocks of various stages, impressions of shells resembling *Orthoceras* in form, but presenting no trace of chambers, are found often abundantly; these were, probably, gigantic Pteropods, closely allied to, if not generically identical with, the existing *Criseis*. The paleozoic genus *Theca* seems also to have been a member of this order. In our oolitic and cretaceous strata we find no traces of Pteropoda. A species of *Cleodora* has been found in our upper tertiaries; abroad other species have occurred in corresponding formations, along with *Criseis*, *Cuvieria*, and *Hyalæa*.

[1] See his Paleontologie Française, Ter. Cret, vol. i.

[1] The group *Tavigati*, indicated by E. Forbes in the account of the Ammonites of Southern India (Geological Transactions, new series, vol. vii.), differs from the Heterophylli in the back, which is furnished with a slightly elevated keel.

Sea urchins abound in the fossil state, especially in cretaceous and oolitic strata. In Britain they first appear in the lias. They become very abundant in the oolites. Many of the oolitic forms are members of still existing genera, but more belong to extinct groups. *Cidaris* and *Echinus*, genera still represented in the British seas, had many members within our area during the lower secondary epoch. The tropical genus *Clypeus* was also present. *Diadema*, *Pygaster*, *Dysaster*, *Discoidea*, and *Nucleolites*, are among the British oolitic urchins. During the cretaceous period new genera appeared in our seas. An entire group—that of which *Salenia* is the type—appeared and vanished. *Cidaris* assumed many and varied forms. *Anancrites* and *Galerites* were especially characteristic of the higher cretaceous beds. Many Spatangacea, especially members of the genera *Spatangus*, *Brissus*, and *Holaster*, were common. *Cassidulus*, *Cassidulus*, and *Nucleolites*, had no known representatives. In the British cretaceous strata few *Echinidæ* have been noted. Those recorded belong to existing genera; which is also the case with the miocene and pliocene species.

The researches of Agassiz have vastly extended our knowledge of the fossil Echinidæ. He has established numerous well-marked genera, many of them of great geological importance, in consequence of their very definite relations with the strata in which they occur. The genera, as defined by the great Swiss naturalist, are, however, far from equal in value, and many of the subordinate divisions can be looked upon only as subgeneric sections at best. Of a great number of them we have no British representatives; indeed, many continental strata, of various formations, are much richer in Echinidæ than any in our own country. The following table will show the distribution in time of the principal genera of *Echinidæ*, British and foreign. The first series of names are those of genera confined to the formations under which they follow in order. The series lower down, placed under brackets, are common to two or more formations, according as the brackets indicate by their extent. Genera, represented by living as well as fossil species, are marked by an asterisk:—

From the preceding table it will be at once observed that the genera which exist in both a living and fossil state, are either such as range through several epochs, always including the tertiary, or such as commenced their existence in the epochs nearest our own time. Thus, with the exception of the genera which are common to the whole of the secondary, the tertiary, and the present epochs, all the types of the oolitic epoch are extinct so are all those common to the oolitic and cretaceous strata, but not ranging higher. So are all those peculiar to cretaceous strata. Among the genera common to the cretaceous and tertiary epochs, however, there are several which are common to those times and the present; and all the tertiary genera which are not found lower down in the geological series, have representatives among living animals.

The absence of true Echinidæ previous to the secondary epoch is a very remarkable fact. It is possible that representatives of this group may yet be discovered in paleozoic strata, but we can hardly expect to find them in such variety as to invalidate the conclusion that they are conspicuously characteristic of secondary, tertiary, and existing times. We find their forms and many of their characters closely imitated, however, by members of the following group; indeed, so closely that many naturalists still regard the fossils which constitute the genera *Archæocidaris* and *Palorchinus* as Echinidæ.

Until lately very few *Asteriadæ* were known in a fossil state. Now about thirty British species are known, and eleven of *Ophiuridæ*. In the Silurian rocks of Wales, Ireland, and the north of England, we find several species of star-fishes, apparently referible to the existing genus *Uraster*. With them Professor Sedgwick has discovered the *Protaster*, the only known fossil representative of the family of Eurvalidæ. *Ophiuræ* also occur. In the oolites several star-fishes are found. The *Ophioderma Egertoni* is a well-known mesozoic species. Other forms occur, as well as *Ophiura* proper, *Amphiura*, and *Aspidura*, in oolitic strata. Several species of *Asterias* are found in beds of the same epoch. In cretaceous epochs numerous star-fishes are found. The genus *Comatula*, or *Stellonter*, is characteristic of the green sands. *Goniaster* of the chalks. The common tropical genus *Ormaster* has several representatives in our chalk. *Ophiuræ* also occur.

In the London clay many remains of star-fishes referible to the genus *Asterias* proper. An *Ophiura* has been discovered in the same formation by Mr. Wetherall. Our newer tertiary Asteriadæ have not been made out.

Abroad, remains of star fishes have been found in the Silurians of North America, in the muschelkalk, lias, and oolites of Germany, in the cretaceous strata of Germany, Sweden, France, and Southern India.

The Crinoidæ are among the most interesting and curious of fossil invertebrata. This important tribe had its greatest development during the paleozoic and secondary epochs, diminishing materially towards the close of the latter, and becoming scant and scarce during the tertiary and historical epochs. They commence their existence with the earliest sedimentary deposits, and arrive at their maximum of development before the close of the paleozoic periods. In the lower Silurians they are fragmentary, but common; in the upper beds of that formation many fine species occur, often well preserved in limestones. *Actinocrinus*, *Cyathocrinus*, *Dimerocrinus*, *Rhodocrinus*, *Eugeniocrinus*, *Taxocrinus*, *Trochocrinus*, and *Hyanthocrinus*, are British Silurian genera. During the Devonian epoch we find the genera *Cyathocrinus* and *Platycrinus*, *Taxocrinus* and *Actinocrinus*. The limestones of the carboniferous period abound in Crinoidem. Numerous species of *Actinocrinus*, *Platycrinus*, *Cyathocrinus*, *Poteriocrinus*, occur, with others of the genera *Rhodocrinus*, *Symbathocrinus*, *Gilbertocrinus*, *Taxocrinus*, &c. The commencement of the secondary period is marked by abundance of *Pentacrinus*, indicative of a new series of Crinoidal forms. At Lyme Regis, where they have been found in great numbers, they occur associated with fossil-wood in such a manner that there can be little doubt that they lived attached to floating masses of wood, probably in shallows. Higher up, among the oolitic strata, we find the curious genus *Apiocrinus* (the Pear Encrinite), which appears to have lived attached to ancient banks of coral. During the cretaceous epoch the free Crinoids seem to appear, and *Comatulæ* seem to have been not uncommon. The genus *Marsupites* is a remarkable form of this group, and disappears before the commencement of the tertiaries. The last of the fossil Pentacrinites appear in eocene strata, but as the genus still lives it is probable that intermediate species will be found. *Comatulæ* existed during all the tertiary epochs. In Britain, however, no trace of it has been found in pliocene strata. The supposed genera of Echinidæ, *Gangonella* of Gray, and *Glenotremites* of Goldfuss, are only the cups of *Comatulæ*.

It may be noted generally respecting fossil Crinoids: *1st*, That all the genera of the family *Actinocrinidæ*) including such as have cups composed of thin and slightly articulated pieces, and having much-divided arms), as *Rhodocrinus*, *Actinocrinus*, *Gilbertocrinus*, *Macrurus*, *Scyphocrinus*, *Cyathocrinus*, *Platycrinus*, *Dimerocrinus*, *Hyanthocrinus*, &c., are confined to paleozoic strata. *2d*, That all the genera of the family *Poteriocrinidæ* (composed of such as have their cups made up of large and strong segments, having general aspect closely resembling the members of the first tribe), as *Poteriocrinus*, *Incrinus*, and *Symbathocrinus*, are paleozoic. *3d*, That the genera of the family *Pentacrinidæ* (characterized by the strongly articulated segments of their cups and head of the column, and by the side arms of the latter) range from the triassic epoch to our own times, having their maximum during the oolitic epoch. *4th*, That the genera of the family *Apiocrinidæ* (characterized by the pear-shaped and articulated summits of the stem and cup, and the naked column), as *Apiocrinus*, *Guettardocrinus*, *Millericrinus*, *Encrinus*, and *Eugeniocrinus*, are secondary, and for the most part oolitic. *Encrinus* is a genus not found in British strata, and characteristic of the trias (muschelkalk). It is the well-known stone-lily, or lily encrinite of collectors. The genus *Bourgueticrinus* of D'Orbigny, of which two species are, however, from the chalk, is an exception to the above rule. It is a genus of a Crinoid, found preserved in the recent blank of the Antilles, be rightly referred to it. *5th*, The free Crinoids, *Comatulidæ*, appear to have ranged from the oolitic period to the present time; for in the lithographic slates of Bavaria we find several remains of animals closely allied to *Comatulæ*. This family appears to have attained its greatest development during our own epoch, and certain living species are known to pass through stages exactly comparable to the adult state of the stalked Crinoid, we must regard the *Comatulidæ* as the most advanced of Crinoidal forms.

The Cystidea are singular Echinidermous fossils, closely allied to the Crinoids, and appearing to form a great and rapidly metamorphosing group, diverging within itself, and conducting from the Crinoids to the Echinidæ and Asteriadæ by a metamorphosis at first apparently retrograde, and repeating the rudimentary forms of the Crinoids themselves. They are essentially paleozoic. Little has been known of them as British fossils until very lately. In the lower Silurians we find four species of *Sphæronites*, three of *Caryocystites*, one of a genus allied to *Cryptocrinites*, and several of *Hemicosmites*. In the upper Silurian, three species of *Sycocystites* occur, and three of *Pseudocrinites*. In carboniferous rocks the curious genera *Palæchinus* and *Archæocidaris* represent the Cystidea, and most probably also the *Pentremites*.

Cystideans occur in the Silurians of Russia, Scandinavia, and North America.

ZOOPHYTA.

When we consider what an important part corals play in the formation of new land, and in the contribution of new material for the sea-bed, it is evident that the study of fossil Zoophytes must be of no small geological importance. Such tribes as have calcareous skeletons are especially valuable to the palæontologist, from the perfection with which their framework may be preserved in the fossil state. Of the soft kind—and they form no inconsiderable part of this class of animals—we cannot expect to find many traces. Numerous Actinen and allied forms, and millions of naked hydroid Polypes might have lived in any or in all ages of the ancient world, yet have left "not a wreck behind." Hence conclusions drawn from geological researches of the comparative ancient and present development of the class must be fallacious and valueless. But the abundance of zoophytic remains contained in many ancient rocks, affords good data for judging of the relations of the earlier preservable forms with those now living belonging to the same tribes. And from these we learn that, on the whole, there has been little, if any change, in the plan of zoophytic organization since the beginning of geological time; that whilst some genera have passed away, and new ones have taken their places, *the earlier forms were as perfect as their successors*. Indeed, among the very earliest, the most perfect forms of Zoophytes play an important a part as the most rudimentary. Most of the zoophytic genera are remarkable for their great duration in time; and this applies also to a great many species, both during paleozoic and tertiary epochs.

In speaking of Zoophytes in connection with geology, it is convenient to use the term so as to include both Zoophytes proper and Bryozoa, although the latter order rightly take their place among Mollusca. Yet these "polypidoms," to misapply the word, are so similar to those of true Zoophytes, that it is almost impossible to draw a line between them when in the fossil state; and even in the living it is at times very difficult to do so, however dissimilar the organization of the creatures might be by which they were constructed.

In the Silurian rocks of Britain we find a considerable assemblage of Zoophytes, both Bryozoa and true Polypes. The monoxylar anomalous genus *Favosites*, and its ally *Chætetes*, are among the first that appear, and are found very low down among the lower Silurians. *Petraia* or *Turbinolopsis* (*thisa*), *Cateniopora* and *Aulopora* are also very early forms. The Cateniporæ enchœnidæ have a very great range, extending into the Devonian rocks abroad. *Favosites Gothlandica* and *Favosites fibrosa* have an equal distribution. So also has the *Porites pyriformis*, and perhaps the *Stromatopora concentrica*. *Syringopora catenaria*, an upper Silurian fossil, ranges into the carboniferous limestone. Species of *Astræa*, *Portia*, *Turbinolia*, *Fungia*, *Millepora*, *Gorgonia*, *Eschara*, *Flustra*, *Pustulipora*, and *Retepora*, show a certain relation between the Silurian fauna and that of the existing period; whilst *Polyphyllum*, *Cyathaxonia*, *Stromboloides*, *Cyclopora*, *Syringopora*, and *Petraia*, give marked and peculiar features to the Silurian zoophytic fauna, though closely allied with that of the upper paleozoic rocks. In the upper Silurians, corals, especially the larger kind, are much more abundant than in the lower, especially in the Wenlock limestone, wherein we find a great variety of forms for the most part exquisitely preserved.

In Devonian strata we find, as already noticed, many Silurian species. Many, however, have disappeared, and become replaced by others. The genus *Astræa* becomes more developed, and *Favosites* are numerous and characteristic. In the limestones of the carboniferous system numerous Zoophytes occur, often forming considerable masses. The species of *Cladochonus*, *Stylodictya*, *Lithodendron*, and *Lithostrotion* or *Columnaria*, especially play a conspicuous part. Numerous minute corals are also preserved in great beauty in the mountain limestones of the north of England, and many parts of Ireland.[1] Species of *Gorgonia* occur in the Magnesian limestone of Durham, and one of these, the *Gorgonia reticiformis*, is common to that rock and the carboniferous limestone.

Taken as a whole, the paleozoic Zoophytes present a marked contrast with those of secondary and tertiary epochs, though so many of the genera are common to all. Among the Silurian Zoophytes are some forms which are yet very uncertain placed, as the genus *Graptolites*, hitherto confined to Silurian rocks, and very characteristic of that formation. The Graptolites appear to have been Sertularian Polypes, but some of the forms have a singular resemblance to some of the varieties of sea-pens, so that it is more than probable that several generic groups have been confounded under one name.

During the oolitic epoch there was a great development of Zoophytes in our seas, though not during its earlier stage; for in the lias polyphloms are rare. In some of the higher beds great assemblages of corals occur. The coral rag is an example. *Astræa* and *Turbinolidæ* are especially abundant. The species are often very similar in habit to existing tropical and Indian Ocean forms. They are associated with numerous Bryozoa—many of them members of existing genera. It is probable that many more species of Zoophytes than have been described will be made known from oolitic strata.

The Zoophytes of our cretaceous rocks have been as yet very imperfectly worked. They are numerous and most interesting, for we find not a few which are very closely allied to existing deep-sea species, especially about the junction of the upper and lower chalk. In the upper green sand corals are common, and many Hetianthoid genera occurs. Bryozoa are more abundant than in previous formations.

Very few British eocene Zoophytes have as yet been made known. As *Astræa* and some *Turbinolidæ* constitute the scanty list. In foreign eocene strata, however, Zoophytes are numerous and varied, as may be seen by the following tables.

From the coralline crag no fewer than fifty-seven species of Zoophytes have been recorded by Mr. Searles Wood. Of these eighteen or nineteen are existing British forms. They are associated with Polyparia and Bryozoa of a more southern character, including species of *Balanophyllia*, *Cladocora*, *Fascicularia*, *Thecosa*, *Hornera*, *Lunulites*, *Fungia*, &c., of which we have now no representatives in our seas. In the red crag only twenty-five species have been observed, and of these fourteen are existing British forms. In beds of the pleistocene epoch still fewer have been found, and all are existing species of northern origin.

Tables showing the distribution in time of the best-marked genera (whether British or Foreign) of fossil Zoophytes. In the last column such as are still represented are indicated. When two or more asterisks occur, a great development of the genus is indicated.

TABLE I.

Species.	Older Paleozoic.	Newer Paleozoic.	Older Secondary.	Newer Secondary.	Older Tertiary.	Newer Tertiary.	Present Epoch.
Eschara	*	..	*	..	..	..	*
Escharina	..	..	..	..	**	*	*
Lepralia	..	..	..	..	..	..	***
Melicertina	..	..	..	..	..	..	..
Tibia	*	..	..	..	..	..	..
Pyrhelopora	*	..	..	..	..	..	..
Membraniporæ	..	..	..	..	..	*	**
Flustra	..	..	..	..	..	*	*
Diastopora	*	..	..	..	..	..	*
Ocellaria	..	..	..	..	..	..	..
Cellepora	..	..	..	..	..	**	***
Margarella	..	..	..	..	..	..	..
Ampullaria	..	..	..	..	..	..	..
Adeonidæ	..	..	..	..	*	..	..
Collaria	..	..	..	..	..	*	..
Glauconome	..	..	..	..	*	..	..
Intricaria	..	..	..	..	*	..	..
Berenicea	..	..	..	..	..	..	..
Verticillopora	..	..	..	..	..	..	..
Tubulipora	..	..	..	..	..	*	**
Crisia	..	..	..	..	..	*	**
Hippothoa	..	..	..	..	..	*	*
Alecto	..	..	..	..	..	*	..
Filisella	..	..	..	..	..	*	..
Hornera	..	*	..	..	..	*	*
Heteropora	..	*	..	..	..	*	..
Pustulipora	..	*	..	..	..	*	..
Diastopora	..	*	..	..	..	*	..
Crisopora	..	*	..	..	..	*	..
Reteporæ	..	*	..	..	..	*	..
Dictyotopora	..	..	..	..	..	*	..
Cuttopora	..	*	..	..	..	*	..
Thamnopora	..	*	..	..	..	*	..
Caryopora	..	*	..	..	..	*	..
Stylopora	..	*	..	..	..	*	..
Orbitulites	..	..	..	..	..	*	..
Lunulites	..	..	..	..	..	*	..

TABLE II.

Asteroid and Echinoidal Polypes.	Lower Paleozoic.	Upper Paleozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Recent.
Alecythium,	..	..	*	..	..	..	*
Parmulata,	..	..	..	..	..	..	*
Gorgonia,	..	..	..	..	..	..	*
Funulata,	..	..	..	..	..	..	*
Astræa,	*	*	*	*	*	*	*
Pelagia,	..	..	..	..	..	..	*
Scrinopora,	..	..	..	..	..	..	*
Millepora,	..	..	..	..	..	..	*
Thecosa,	..	..	..	..	..	..	*
Stromatopora,	*	*	..	..	..	..	..
Favosites,	*	*	*	*	*	*	*
Chætetes,	*	*	..	..	..	..	..
Ida,	..	..	..	..	..	..	*
Oculina,	..	..	..	..	..	..	*
Explanaria,	..	..	..	..	..	..	*
Cladocora,	..	..	..	..	..	..	*
Columnaria,	*	*	..	..	..	..	..
Stromboloides,	*	*	..	..	..	..	..
Cyathophyllum,	*	*	..	..	..	..	..
Michelinia,	*	*	..	..	..	..	..
Montivaltia,	..	..	..	..	..	..	*
Cyathylithus,	..	..	*	*	*	*	*
Caryophyllia,	..	..	..	..	..	..	*
Astræa,	*	*	*	*	*	*	*
Thamnastræa,	*	*	*	*	*	*	*
Porites,	*	*	*	*	*	*	*
Fungia,	..	..	..	..	..	..	*
Turbinolia,	..	..	..	..	..	..	*
Petraia,	*	*	..	..	..	..	..
Cyathina,	..	..	..	..	..	..	*
Asteropora,	*	*	..	..	..	..	..
Monticulipora,	*	*	..	..	..	..	..
Favosites,	*	*	*	*	*	*	*
Agaricia,	..	..	..	..	..	..	*
Montlivaltia,	..	..	*	*	*	*	*
Heteropora,	..	..	..	..	..	..	*
Madrepora,	..	..	..	..	..	*	*
Cladocora,	..	..	..	..	..	..	*
Syringopora,	*	*	..	..	..	..	..

AMORPHOZOA.

The sponges may be regarded as the lowest among animal forms. They are compound beings; masses of animals of the simplest structure, each individual of the nature of the microscopic *Protens*, which is a simple form in the amorphozoic group. The term *Amorphozoa* is, however, very inappropriate, when applied to such exquisitely symmetrical creatures, or combinations of creatures, as the *Foraminifera*, members of this group, though long, from the resemblance of their shells to Nautili, supposed to be Mollusca of the highest class.

The Sponges, properly so called, are but indistinctly indicated in the oldest sedimentary strata. *Cnemidium tenue* (Lonsdale) is a Silurian fossil supposed to belong to this tribe. *Manon ordovicum*, and *Scyphia turbinata*, are British Devonian fossils. Traces of Sponges occur in the carboniferous

[1] The works of Phillips and M'Coy should be consulted for these fossils.

TABLE OF MOLLUSCA ACEPHALA.—*Continued*

Mollusca Acephala.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present.	Habitat of the Genus.
Solenya,	—	—	*	*	*	*	**	Shallows, littoral, and moderate depths.
Sedgwickia,	—	—	*	*	*	*	**	Do. do.
Solenocurtus,	—	—	*	*	*	*	**	Do. do.
Lyonsia,	—	—	*	*	*	*	**	Do. do.
Anatina,	—	—	*	*	*	*	**	Do. do., and deep sea.
Thracia,	—	—	*	*	*	*	**	Do. do.
Sphenia,	—	—	*	*	*	*	**	Shallows, to very deep sea.
Corbula,	—	—	*	*	*	*	**	Deep sea.
Neæra,	—	—	*	*	*	*	**	Shallows, to considerable depths.
Perna,	—	—	*	*	*	*	**	Littoral, in mud.
Pandora,	—	—	*	*	*	*	**	Various depths; from littoral to extremely deep sea.
Lutraria,	—	—	*	*	*	*	**	Moderate depths.
Amphidesma,	—	—	*	*	*	*	**	Moderate and considerable depths.
Sanguinolaria,	—	—	*	*	*	*	**	Littoral; Shallows, and considerable depths.
Psammobia,	—	—	*	*	*	*	**	Littoral.
Tellina,	—	—	*	*	*	*	**	Various depths.
Donax,	—	—	*	*	*	*	**	Littoral.
Mesodesma,	—	—	*	*	*	*	***	Littoral, and moderate depths.
Macoma,	—	—	*	*	*	*	***	From littoral to very deep sea.
Mactra,	—	—	*	*	*	*	***	Shallows, and moderate depths.
Venus,	—	—	*	*	*	*	**	From shallows to very deep sea.
Cytherea,	—	—	*	*	*	*	**	Moderate depths.
Astarte,	—	—	*	*	*	*	*	?
Crassatella,	—	—	*	*	*	*	*	Various depths; mostly littoral.
Megalodon,	—	***	*	*	*	*	*	Sands; and on reefs.
Cardinia,	—	**	*	*	*	*	*	?
Cardita,	—	*	*	*	*	*	*	Various depths; in mud.
Opisthodon,	—	*	*	*	*	*	*	?
Hippopodium,	—	*	*	*	*	*	*	?
Isocardia,	—	*	*	*	*	*	*	Littoral, to considerable depths.
Clathrocardia,	—	**	*	*	*	*	***	?
Hippagus,	—	*	**	*	*	*	*	?
Cardium,	—	*	*	*	*	*	**	Shallows, and littoral, on rocks and reefs.
Hippurus,	—	*	*	*	*	*	*	?
Carbilia,	—	*	*	*	*	*	*	Littoral, or shallows?
Tridacna,	—	—	*	*	*	*	***	Littoral, and moderate depths; some species on reefs.
Otis,	—	—	*	*	*	*	*	?
Corbis,	—	—	*	*	*	*	*	Various depths.
Lucina,	—	*	*	*	*	*	*	Fresh-water.
Diplodonta,	—	—	*	*	*	*	*	Do.
Cyclas,	—	—	*	*	*	*	**	Littoral, to very deep.
Cyrena,	—	—	*	*	*	*	**	Shallows, and moderate depths.
Kellia,	—	—	*	*	*	*	**	All depths. The deepest living genus known, of this order.
Lepton,	—	—	*	*	*	*	**	?
Nucula,	*	*	*	*	*	*	**	Moderate depths.
Limopsis,	—	—	*	*	*	*	***	From the water's edge, to the greatest depths.
Pectunculus,	—	—	*	*	*	*	*	Littoral, and deep sea.
Arca,	*	*	*	*	*	*	*	Littoral; boring.
Mytilus,	—	—	*	*	*	*	*	?
Ethmodonta,	—	—	*	*	*	*	*	?
Ethmolithe,	—	**	*	*	*	*	*	?
Myoconcha,	—	—	*	*	*	*	*	Sub littoral, and at considerable depths.
Sanguinolites,	—	*	*	*	*	*	*	Fresh-water.
Perna,	—	—	*	*	*	*	*	On rocks, littoral, and shallows.
Dreissena,	—	—	*	*	*	*	*	?
Chama,	—	—	*	*	*	*	*	Fresh-water.
Diceras,	—	—	*	*	*	*	*	Shallows, to considerable depths.
Etheria,	—	—	*	*	*	*	*	?
Avicula,	—	*	*	*	*	*	*	?
Pinfuria,	—	*	*	*	*	*	*	Moderate depths, and on corals.
Pinidenta,	—	—	*	*	*	*	*	?
Crenatula,	—	—	*	*	*	*	*	?
Perna,	—	—	*	*	*	*	*	?
Gervillia,	—	—	*	*	*	*	*	?
Inoceramus,	—	—	*	*	*	*	*	?
Vulsella,	—	—	*	*	*	*	*	From shallows to very great depths.
Lima,	—	—	*	*	*	*	***	Do. do.
Pecten,	—	—	*	*	*	*	***	Do. do.?
Hinnites,	—	—	*	*	*	*	*	Moderate depths.
Plicatula,	—	—	*	*	*	*	*	Shallows, and moderate depths.
Spondylus,	—	—	*	*	*	*	*	Various depths.
Anomia,	—	—	*	*	*	*	*	?
Gryphæa,	—	—	*	*	*	*	*	Sandy bottoms; shallow?
Ostrea,	—	—	*	*	*	*	*	Various depths, and littoral.
Aetheria,	—	—	*	*	*	*	*	?
PALLIOBRANCHIATA.								
Cephalotus,	—	—	—	—	—	—	?	?
Cuprina,	—	—	—	—	—	—	?	?
Ichthyosarcolites,	—	—	—	—	—	—	?	?
Hippurites,	—	—	—	—	—	—	?	?
Radiolites,	—	—	—	—	—	—	?	?
Crania,	—	—	*	*	*	*	*	Usually very deep sea.
Orbicula,	—	—	*	*	*	*	*	Shallows, and deep sea.
Obolus,	—	—	*	*	—	—	—	?
Odontis,	—	—	*	*	—	—	—	?
Thecidea,	—	—	*	*	*	*	*	Deep sea.
Productus,	—	***	—	—	—	—	—	?
Chonetes,	—	***	—	—	—	—	—	?
Leptæna,	—	**	*	—	—	—	—	?
Orbicula,	—	**	*	*	*	*	*	Probably (by analogy) deep sea.
Spirifer,	—	***	—	—	—	—	—	?
Pentamerus,	—	—	*	—	—	—	—	Probably deep water.
Strigocephalus,	—	—	*	—	—	—	—	?
Terebratula,	—	**	*	*	*	*	*	Littoral to great depths. The majority of species very deep sea.
Lingula,	***	*	*	*	*	*	*	Shallows, and moderate depths; probably entirely in great depths.

TUNICATA.

Evidences of the existence of this important order of Molluscs in the fossil state are very obscure, as might be expected when the unpreservable nature of the living forms of the order is considered. The Silurian genus, *Ischadites*, was supposed to be possibly a form of Tunicated Molluscs, but the evidence is by no means clear, and many of the characters of those remarkable fossils would rather indicate their relationship with the *Cystidea* among the Echinodermata, than with any division of Molluscs.

CRUSTACEA.

The preservable nature of the integuments, and the aquatic habits of the majority of the species of Crustacea, render this class of articulate animals peculiarly interesting to the palæontologist. Remains of Crustacea occur in formations of all epochs, but the majority of the palæozoic species are very different from any existing forms, and belonging, as they do, to the division called *Palæadea* or Trilobites, are peculiar to, and highly characteristic of, palæozoic fossiliferous rocks.

Trilobites were first made known by British observers, and first discovered in South Wales. The writings of Edward Lhwyd, published about the middle of last century, contain the earliest papers on these interesting fossils. Those he described were from Silurian rocks. The following are the Silurian genera found in Britain :—

Trinucleus.—Four or five species, mostly lower Silurian.

Asaphus.—Three or four species.

Ogygia.—Two species, lower Silurian. *Ogygia Buchii* is highly characteristic of the Llandeilo flags.

Paradoxides.

Olenus.—(With *Remopleurides.*)

Chirurus.

Agnostus.—Three or more species.

Lichas.

Harpes.—The species of this genus are from the Silurians of Ireland.

Calymene.—The *Calymene Blumenbachii* is the well-known Dudley Trilobite, and has a great vertical extension in the Silurian system, as well as a very wide geographical distribution. There are several other British species.

Homalonotus.—A genus highly characteristic of upper Silurian rocks, and ranging into the Devonian.

Sphærexochus.

Cybele.—Several species.

Phacops.—Several species.

Proetus.—Several species. The genus *Forbesia* of M'Coy falls here.

Bronteus and *Dionurus.*—Several species; two of the former section usually lower Silurian, and among the oldest of Trilobites.

Acaste, several species.

The only other Crustaceous found in our Silurian rocks are Ostracoda of the genera *Cythere* and *Beyrichia*. The curious genus *Pterygotus* is probably crustaceous.

In our Devonian strata several Trilobites occur. *Bronteus flabellifer* is one of the most remarkable and characteristic. *Harpes macrocephalus* is another striking form. Several species of *Phacops* also occur. Some remarkable Crustaceous are found in the old red sandstone.

In our carboniferous rocks the allied genera, *Griffithides* and *Phillipsia* include all the Trilobites of their epoch. They occur in the mountain limestone. Numerous Crustaceous of other tribes however, make up for the paucity of Trilobites. The genera *Dithyrocaris*, *Eurypterus*, *Cythereis*, *Daphnia*, *Beyrichia*, and *Cythere* (the last, including a long array of species), are enumerated by M'Coy as occurring in the mountain limestone of Ireland. The genus *Limulus* occurs in the coal measures of Coalbrook Dale, and *Eurypterus* in the Scottish coal measures. Several species of Cypris occur in the English coal measures. An *Apus* is recorded by Mr. Prestwich among Coalbrook Dale fossils.

Few Crustaceans are recorded from the British oolitic strata. Such as are, chiefly belong to the *Macrura*. They include the *Coleia antiqua* of Beckeridg, and the *Glyphæa tuisana*, from the lias of Lyme, and several species referred to *Astacus* by Phillips, from various oolitic beds in Yorkshire. In the Wealden species of *Cypris* occur in greater plenty, also Isopodous Crustaceans.

Many Crustacea have been found in our cretaceous rocks. Some of the lower beds of the lower green sand, in the Isle of Wight, abound in remains of *Astaci*, often in tolerable preservation. *Astaci* also occur in the upper green sand, and in the chalk. An *Eryon* has been found in the chalk at Staining, and an *Eryon* in the gault. *Pagurus Faujasi*, and *Scyllarus Mantelli*, are also British chalk Crustaceans.

The London clay of Sheppey abounds in Crustacean remains. Among these are both Macrourous and Brachyurous species; but very few of the forms found have as yet been described. The recorded species are referred to *Cancer*, *Inachus*, and *Dromia*. The *Cytherina barbata* is a London clay fossil.

In our newer tertiaries such remains of Crustacea as have occurred belong to existing genera, and mostly to existing British species. Among the latter are the *Ebalia Bryeri*, *Pagurus Bernhardus*, and *Cancer pagurus*.

Many more fossil Crustaceans are recorded from foreign than from British strata. *Brachyura* are recorded from cretaceous strata in Europe and America, and many species have been found in tertiaries of Europe and of India. A few Anomurous Decapods have been found in the tertiaries of all ages. The Macrourous genus *Pemphix*, is only known in the muschelkalk. The lithographic slates of Germany contain numerous forms of *Macroura*. Of *Stomapoda*, a species of Squilla is recorded from the slates of Monte Bolca. The Amphipodous genus *Typhis*, is represented in the tertiaries of North America. Terrestrial *Isopoda* are preserved in the amber of Northern Germany. Several Isopodous genera occur in the German lithographic slates. Trilobites occur abundantly in foreign palæozoic rocks in both hemispheres; and many generic forms are found of which we have no British examples. Cyproid Crustaceous occur in foreign beds of various ages. *Xiphosura* are found in the muschelkalk and jurassic beds of Germany.

CIRRHIPEDA.

The most ancient of our Cirrhipeda are species of *Pollicipes*, recorded by Morris and by Buckman from the oolitic strata. This genus is represented also in the lower green sand, the gault, the chalk, and the London clay. The *Lepicula spinchilla* of George Sowerby is a remarkable pedunculated Cirrhiped from the white chalk. *Balani* occur in the London clay, the red and coralline crag, and pleistocene beds. All the newer tertiary species appear to be identical with existing forms. The genera *Acasta*, *Adna*, and *Scalpellum*, all occur in the coralline crag, and *Clitia* and *Coronula* have been found in the red crag.

Few Cirrhipeda have occurred in foreign localities. Roemer records a number of *Pollicipes* from the cretaceous beds of Northern Germany; and Phillippi enumerated several Cirrhipeds, both pedunculated and sessile, from Mediterranean tertiaries. Species of *Balanus* have been found in tertiary beds of North America and of India.

INSECTA.

The remains of insects, like those of other inhabitants of the dry land and air, are comparatively rare in the fossil state, their preservation in sedimentary deposits being mostly accidental. Such as are found chiefly occur in fresh-water formations. The first remains of insects occur in the coal measures of Coalbrook Dale. Of these, two have been described by Dr. Buckland as species of Curculioides, a genus founded for them on account of their resemblance to weevils, though Professor Pictet doubts their true relationship to this tribe. With them the wing of a Neuropterous insect has been taken. In the lias of Gloucestershire numerous remains of insects have been discovered, especially by Mr. Brodie, who has published an interesting account of them in his "History of British Fossil Insects." They belong to ten species, members of the orders Coleoptera, Neuroptera, Orthoptera, and Diptera. In the Stonesfield slate, Mr. Brodie has found a *Prionus* and a *Coccinella*. The same gentleman has discovered no fewer than twenty species of insects in the Wealden, representatives of many orders and tribes. None have, as yet, been observed in British deposits of the cretaceous epoch; nor have the British eocene tertiaries, not even those of fresh-water origin, yielded any. The red and coralline crags are equally barren in insects. In the fresh-water plocene of Mundesley, Mr. Lyell has found remains of the genera *Cupris*, *Donacia*, and *Harpalus*. Remains of insects are frequent in peat.

Abroad, the most ancient fossils of this order have been found in jurassic beds, especially in the lithographic slates of Bavaria.[1] Traces of insects have been observed in the cretaceous slates of Glaris, and Elytra of Coleoptera have been found in the chalk-marl of Normandy. Our knowledge of the insect fauna of the fertiary epoch is chiefly derived from some continental beds, especially those of Aix in Provence, the marls of Œningen, and the lignites of the neighbourhood of Bonn.[2] By far the most prolific source of fossil insects is, however, the amber of the Baltic shore, a fossil resin, the produce of the *Pinus Succinifer*, an extinct tree of the eocene epoch. In this resin, when fresh, insects and even small reptiles became entangled, and thus have been preserved in the most perfect condition. It is evident that from such materials, since they are abundant, we acquire good data for judging of the state of life in central Europe in the early stage of the tertiary epoch. The researches of Dr. Berendt and Professor Pictet have made known to us the results. The conclusions of the latter naturalist, respecting Neuropterous insects found in amber, will serve to show the light they throw upon the terrestrial, or rather aerial eocene fauna. He states, that they are all either species very near to, but not identical with, living Russian forms—or forms (extinct) characteristic of inter-tropical and mediterranean climates—or members of extra-European genera, some even American—or members of entirely new genera, the last being comparatively few. Professor Pictet has remarked, respecting fossil insects generally, that though the remains are few, there is every reason to think that this class was enormously represented in ancient epochs, especially during the tertiary times; and he does not doubt their abundance during more ancient geological periods, although their destruction appears to have been almost total. The weakness of their integuments, and the minuteness of the majority of the tribe, would go far to account for the rarity of their preservation.

ANNELIDA.

The majority of true worms being soft-bodied animals, are not very likely to be preservable in a fossil state, consequently we find but few traces of this important class of articulate animals. Many of them, however, when trailing over the soft sands and muds, on which they usually live, leave impressions of their course sufficiently distinct to mark the order, and, in some cases, the genus to which the creature belongs. Such impressions made by existing worms in the sea-shore, have been found in the sandstone and shales of various ancient formations, and we have every reason to believe that they were made by similar creatures. In the oldest fossiliferous beds of the Silurian system in Wales, such impressions occur. The names *Nereites* and *Myrianites* have been given to them. Several species have been distinguished. With them are found impressions which have been referred to the trails of Abranchous Annelides; to these the name of *Nemerites* has been given. Similar trails occur among oolitic rocks, and, when searched for more carefully, will probably be found very generally in rocks of all ages.

The remains of Annelides constructing shelly tubes occur in rocks of all ages. They have been distinguished into genera and species; but this determination, judging from recent researches upon the existing forms of tubiculous Annelides, will probably rest for ever uncertain and empirical. We now know that among the tubicolous Annelides very different animals inhabit very similar shells, that the difference being often of generic importance. Arguing from analogy, then, it will be quite impossible to judge of the palæontological connection of two or more formations, by the presence in them of forms apparently identical of shells of this order. But, though useless in a chronological point of view, they may be of importance in determining the circumstances of depth and conditions under which a stratum was deposited, for we find that many of the existing forms afford very certain indications of depth.

Fossils referrible to the genus *Serpula*, using the word in its widest and Linnæan sense, occur in the British Silurians (*Spirorbis Lewisii*); in the carboniferous limestones (many species, especially in Ireland); in the various strata of the oolitic period (23 British species recorded); in the cretaceous rocks (23 British species); in the eocene tertiaries (8 species); and in the newer tertiaries, where the forms are such as to indicate every probability of their being identical with existing species.

In searching for fossil Serpulæ, the operculum should be carefully looked for, since it affords the best indication of the generic relations of the shell; but few opercula of fossil Serpulæ have as yet been described.

Nearly allied to Serpulæ is the genus *Ditrupa*, a group of shells so closely resembling *Dentalia*, that until the animal constructing them was made known by Berkeley, they were supposed to belong to the Molluscs Gasteropods. By some mistake they have lately been enumerated in geological works and catalogues as Pteropodous Molluscs. Well-marked species of *Ditrupa* occur in the British tertiaries. The *Ditrupa plumosa* is remarkable as the first fossil which occurs in abundance in our eocene beds. It is probable that the palæozoic fossils to which the generic appellations of *Serpulites* and *Euniclus* have been applied, are the shells of animals very closely allied to the *Ditrupæ*. The *Serpulites longissimus* is a very curious and characteristic Silurian fossil.

Numerous testaceous Annelides, not hitherto observed in British formations, are described in the works of foreign authors. Devonian Serpulidæ have been figured by Goldfuss: also muschelkalk species. The same author gives forty-three liassic and jurassic species from Germany. De Koninck has figured several forms of Spirorbis from the carboniferous rocks of Belgium. Above fifty forms of cretaceous Serpulidæ have been observed in Germany and France. Fossil Ditrupæ occur in the green sand rocks of Southern India. Many Continental and American tertiary Serpulidæ are figured.

ECHINODERMATA.

The following table exhibits the comparative development of the orders of Echinoderms during the several geological epochs and the present time within the area of the British Islands. The absence of fossils of the two highest orders during former epochs is not to be attributed to absence of animals of those types, but rather to their unpreservable nature. The great development of the Echinidæ during the central epochs is a very important fact clearly made out. The undeveloped condition of the *Asteriadæ* and *Ophiuridæ* during geological epochs, as contrasted with the present, may depend only on their comparatively unpreservable nature, and not on absence. The great development of the Cystidea during the earliest periods is unmistakable. So also is the far greater importance of the Crinoidea anciently than now. As a whole, the Echinoderms afford decided indications of higher temperature within our area during the secondary epochs, and of the diminution of that temperature during the tertiaries, till it reached a minimum in the pleistocene period and rose again with our own. The indications they afford of the climate of the palæozoic epoch are not so clear.

Orders of Echinodermata.	Lower Palæozoic.	Upper Palæozoic.	Lower Secondary.	Upper Secondary.	Lower Tertiary.	Upper Tertiary.	Present Epoch.
Sycocrinidæ,	*	*	—	—	—	—	—
Holothuriadæ,	—	—	—	—	—	—	***
Echinidæ,	*	*	***	***	***	***	***
Asteriadæ,	*	*	*	**	*	*	***
Ophiuridæ,	*	*	*	*	*	*	***
Cystidea,	***	*	—	—	—	—	—
Crinoidea,	***	***	**	*	*	*	*

Although *Holothuriadæ* have not been found in a fossil state, it is not improbable that the peculiar calcareous specula which stud their skins may yet be found among microscopic remains.

[1] See the papers of M. Germar, in the Nov. Act. Acad. Nat. Cur. t. xix.; and the fifth part of Count Münster's Beiträge.

[2] See Murchison, in Jameson's Journal, 1839, and the 3d vol. of the Geological Transactions, 2d series; also the various lists of Rozzel de Serres, Germar, and Schübler.

limestone of Ireland. They become frequent and well-marked in oolitic strata of marine origin, often closely simulating existing forms. In cretaceous rocks they are still more abundant, especially in the upper green sand. Thirty-nine British species are named. Most of these appear to have been structurally allied to existing genera; but the supposed Sponges, called *Ventriculites*, from the chalk, have been lately shown, by Mr. Toulmin Smith, to present peculiarities of structure very distinct from any organization yet discovered among these bodies.[1] The researches of Mr. Bowerbank have made known the microscopic structure of numerous Sponges included in chalk flints, and have shown that, in the majority, the organization is very similar to that presented by existing species. Very few Sponges have as yet been found in the British tertiaries.

On the Continent, between twenty and thirty Sponges have been described from palæozoic strata, and a very great number from secondary rocks.[2] Tertiary sponges have been described by Phillippi, Michelotti, and Michelin.

As our knowledge of the distinguishing characters of existing Sponges is as yet very imperfect, and as the characters upon which species have been founded are in a great measure empirical, the determination of the limits of fossil species is consequently very unsatisfactory, and must not be used in the solution of geological problems without the greatest caution.

FORAMINIFERA have been observed by Professor Phillips in the Devonian limestones of Cannington Park and South Devon. They have been found also in limestones of the carboniferous epoch in Britain. Mr. Strickland has described species from the oolites. It is, however, in the cretaceous strata that we first find the species numerous, and many of them very near—some, perhaps, undistinguishable from existing forms. Thirty British cretaceous species are enumerated in Mr. Tennant's catalogue, belonging to the genera *Bulimina* (4 species), *Cristellaria* (1), *Dentalina* (3), *Gaudryina* (1), *Globigerina* (2), *Marginulina* (1), *Rosalina* (3), *Rotalia* (7), *Spirolina* (1), *Tectularia* (3), *Truncatulina* (1), *Turbinulina* (1.) Foraminifera play an important part in the London clay; but the species have not as yet been carefully investigated. The most important are the Nummulites (*Nummularia elegans, Nummularia laevigata*, or *Nummularia orbicularis*) which are found in vast numbers in certain beds. The *Foraminifera* of the coralline and red crags have been investigated by Mr. Searles Wood. Several of them are identical with existing species.

On the Continent, Foraminifera occur in vast abundance, in formations of various ages, and have been studied with more attention than in Britain. Alcide D'Orbigny and Ehrenberg are the great authorities on this branch of palæontology. The *Fusulina cylindrica* is a Foraminifer which plays an important part in the upper carboniferous limestone of Russia. The genus *Webbina* has been observed in the lias. Seven species of *Cristellaria* have been found in the "calcaire a polypiers" (oolitic) of Caen. Numerous cretaceous species have been described from France and Germany, and the great nummulitic limestone of the Mediterranean region. Egypt and Central Asia are characterized by the abundance of individuals of *Nummulinæ*. M. A. D'Orbigny has enumerated no fewer than 250 species of cretaceous Foraminifera belonging to thirty genera. In the tertiary strata of the eocene and miocene periods they are extremely abundant. No fewer than 400 species, belonging to fifty-five genera of tertiary Foraminifera, have been enumerated by D'Orbigny. This naturalist has described 900 living species of this tribe. No doubt numerous forms, both living and fossil, remain unrecorded. On the whole, however, we may fairly assert, that the greatest development of these very low but beautiful organisms is in the existing period, and that their numbers increased in successive epochs as we approached the present; in this respect contrasting with the highly organized Cephalopoda, whose shells they simulate, and who were much more numerous and varied during the earlier than during the later epochs of the earth's history.[3]

[1] See Annals of Natural History for August 1847.

[2] See especially the figures in Goldfuss, Petrifacta Germaniæ, vol. i.; in Michelin's Iconographie Zoophytologique; and the works of Roemer on the Oolitic and Cretaceous Formations of North Germany.

[3] The student of the Foraminifera should consult the works of M. D'Orbigny. His volume on the Fossil Foraminifera of the Vienna tertiaries will be found most useful, since it presents a very complete view of the present state of the subject. In Britain we have much to hope from the researches of Mr. Williamson.

INFUSORIA.—The British fossil animals of this tribe may be mentioned here. Many species of Xanthidium occur in chalk flints, also species of the genera *Chartotypkla, Frayilaria, Peridinium*, and *Pyxidicula*. Fossil Infusoria have been observed in pleistocene marls in Ireland, and in North Wales. Very little has as yet been done in Britain towards their investigation. They are, in all probability, abundant in many strata, both tertiary and more ancient.

On the Continent, the researches of Ehrenberg have made known numerous fossil microscopic bodies of this order. They have been found in countless numbers in the substances called Tripoli and Berg-mehl, forming silicious deposits of considerable extent and thickness. In Africa, Asia, and America, they have been observed in equal abundance. The eatable earths of several countries are composed of their remains.

PLANTS.

(See Table of British Fossil Plants on Map.)

The oldest traces of vegetable remains are supposed to be the fucoids of the Silurian beds, but there is no clear evidence of their vegetable nature. Our knowledge of Devonian plants is still very obscure. Not so, however, as respects the flora of the carboniferous epoch, at least, so far as variety of external forms affords evidence of its extent. Our acquaintance with the internal structure and essential characters of the majority of fossil plants is, in reality, very limited, and likely to remain so. Still, the peculiar characters of the fossil forms, the *Calamites, Sigillariæ, Lepidodendra, Stigmariæ*, &c., of the coal measures, though often empirical, are of very great value to the geologist, and indicate very peculiar conditions of the earth's surface. The existence of such enormous quantities of coal itself, bears witness to the extent of vegetation during the epoch of its production. Dicotyledonous trees, especially *Gymnosperms*, allied to the pines and *Araucariæ* of our own times, seem to have been abundant during the same period. The Permian flora has distinct relations with the carboniferous. Of the triassic plants we know but little. In our oolitic strata we find numerous remains of plants, the general assemblage presenting as peculiar a *facies* as that of the carboniferous period. Peculiar forms of Ferns, species of the genera *Pecopteris, Sphenopteris, Pachopteris, Taxiopteris, Phlebopteris, Otopteris, Neuropteris* (1), *Cyclopteris*, and *Alethopteris* mark the epoch. The presence of many species of *Cycadaceæ* within our area is another striking feature of the oolitic flora. Coniferæ and more typical forms of Dicotyledons also occur, and remains of several distinct Monocotyledonous genera. In the Wealden we find species of *Sphenopteris, Lonchopteris, Pterophyllum, Equisetites, Clathraria*, &c. Several plants, *Cycadaceæ* and *Coniferæ* especially, occur in cretaceous beds; and it is an important fact, that one of the Wealden forms ranges to the upper beds of the lower green sand. The researches of Mr. Bowerbank, in the London clay, have made known a vast number of vegetable remains, and have given us as complete an idea of the vegetation of our area during the eocene period as we have of its carboniferous flora. Our eocene flora appears to have been comparable with that now existing in tropical regions of the East. Remains of Palms, Leguminous plants, and Cypress-like Coniferæ, especially characterize it. We have few data, scarcely any, wherewith to judge of the British miocene flora; but we have every reason to believe, that during the pliocene epoch it resembled that now found in the south of Europe, and that during the pleistocene it was composed of arctic and subarctic species, such as now live in the most northern districts of Europe, and a few of which still remain with us, surviving in the summits of the Scottish and Welsh mountains, which once were islands in the ice-bound pleistocene ocean.

GENERAL NOTE.—Consult, for British fossils generally, Morris's Catalogue of British Fossils, and that of Tennant. In Mantell's Medals of Creation much information will be found. Pictet's Manuel de Palæontologie is the best summary of the state of our knowledge of organic remains. Bowerby's Mineral Conchology contains figures of the greater number of described British fossil shells. See also Miller and Austen's Crinoidea.

EXPLANATION OF THE PLATES.

The Palæontological Map of the British Islands presents the following features:—

1. The area occupied by, and the bounds of, the several geological formations (exclusive of the drift), whether of sedimentary or igneous origin, in the British Islands, laid down from the researches of our ablest geologists.[1]

2. The names of places on the map are for the most part geological localities, either such as are mentioned in geological memoirs, or such as are remarkable for the organic remains found in localities in their neighbourhood.

3. Localities remarkably productive in fossils are marked with asterisks and letters, or signs indicative of the nature of the organic remains which occur in such places.

4. Around the coast the more remarkable or most abundant fossils of the neighbouring country are indicated.

[1] The maps of Greenough, Phillips, Murchison, Griffith, M'Culloch, and the published sheets of the Geological Survey, as well as the numerous maps accompanying special geological memoirs, have been consulted as authorities. The plan of the maps in the PHYSICAL ATLAS, however, differs materially from that of any published geological map of Great Britain or Ireland.

5. The more remarkable phenomena of distribution of life during the pleistocene or glacial epoch, especially such as bear upon the distribution of the existing flora and fauna, are indicated at length in their places, terrestrial and marine, where they occur.

6. Lines of depth are traced around the coast, to mark, as far as possible, on the scale of the map the several zones of depth (Littoral, Luminarian, Coralline, and deep-sea Coral), in the British seas.

7. General and special tables of the numerical distribution of fossils in the principal districts are engraved on the margins. These should be consulted in connection with the text.

8. On the upper margin of the map figures of some of the most remarkable palæozoic, secondary, and tertiary fossils, especially Vertebrata, are engraved.

9. On the lower margin figures of the types of the several groups of the genus Ammonites (see "Cephalopoda" in the text) are engraved. These have been selected for illustrations, on account of the neglect the important generalizations and definitions on this subject, by the illustrious Von Buch, have met with in this country.

10. The elevation of the principal mountains and high regions is stated on the map, in feet above the level of the sea.

PHYSICAL CHART

OF

THE ATLANTIC OCEAN.

FOUNDED ON THE RESEARCHES OF

HUMBOLDT, RENNEL, LARTIGUE, HORSBURGH, PURDY, ROMME, SCORESBY, AND THE JOURNALS OF THE OFFICERS OF THE ROYAL PRUSSIAN MERCANTILE MARINE.*

* These comprise various circumnavigations, as well as numerous voyages to North and South America and the West Indies; the original journals of which, by Captains Bolz, Hartmann, Kaehne, Martin, Reinstruck, Rinck, Schleef, Stewart, Wendt, &c., were kindly communicated by the Chief of the Seehandlungs Institute, Private State Minister Ruhmer.

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INTRODUCTION.

THE ATLANTIC OCEAN occupies the great longitudinal valley between the western coasts of Europe and Africa and the eastern shores of America; bounded on the north by the Arctic Circle, and divided from the Pacific Ocean by lines drawn from Cape Horn and Cape Agulhas to the Antarctic Circle. Humboldt supposes this valley to have been formed by a violent rush of waters from the south, which, repulsed by the mountainous coasts of Brazil, were directed to the shores of Africa, and thus formed the Gulf of Guinea; here, again, turned to the westward by the high coasts of Upper Guinea, the stream gave rise to the Caribbean Sea and the Mexican Gulf; whence it continued its course between the mountains of North America and Western Europe, till its force was spent on reaching the Arctic Sea.

THE OCEAN CURRENTS perform a most important part in the economy of nature, and a knowledge of them is of the utmost consequence to navigation. And as the currents of the Atlantic are better known than those of the Pacific or Indian Ocean, we shall here give such general explanations as will be found applicable to the succeeding sheets of this Division. No part of the ocean is in a state of rest—its whole surface is perpetually agitated—one of the wise provisions of the great Author of the universe for preserving its purity. Not only do these currents prevent stagnation in the sea, but by dispensing heat and moisture, they temper the climates over a vast portion of the globe. The existence of ocean currents has been long known; yet it is only since the later improvements in navigation, especially by the introduction of the chronometer and lunar observations, about the year 1770, that they have been treated as a regular and extensive system; and for this we are chiefly indebted to the valuable researches of Major Rennel. Notwithstanding the many attempts to account for the formation of these great systems of aqueous circulation, the subject is still involved in considerable obscurity. The prevalent opinion is that advanced by Rennel, who supposes that they are produced by the pressure of the trade-winds, and the consequent accumulation of water near the Equator. But many examples which he himself adduces, prove this opinion to be untenable. For instance, such an accumulation of water could only produce a superficial current; while he shows that many of the stream currents reach to a very great depth—probably to the bottom of the sea.[1] Besides, many of the currents have their origin in regions where there are no trade or periodical winds. Among other causes to which they have been attributed by recent authors, there are, in addition to the trade-winds, the changeableness of atmospheric pressure, the temperature of the air, the difference of temperature or saltness of the sea, the periodical melting of the Polar ice, the unequal amount of evaporation at different latitudes, and the local forms of the continents. Humboldt, ascribing their formation to the diurnal rotation of the globe, calls them *currents of rotation*. Doubtless, many of these causes may combine to produce the result; but the laws which govern the motion of fluids in large bodies, when moving through each other in currents of different temperatures, are not yet sufficiently understood to warrant a satisfactory explanation of these wonderful phenomena. Future investigations will, in all probability, develop a system of marine circulation in perfect harmony with the other ascertained laws of the universe; but, in the meantime, we shall content ourselves with describing only what is certainly known.

Rennel distinguishes two kinds of currents. *First*, The *Drift Current*, which is merely the effect of a constant or prevailing wind on the surface of the ocean, and therefore penetrates to no great depth. It is proportionally slow in its motion—perhaps not more than half a mile per hour—and is liable to be turned from its course by the obstruction of land, sand-banks, or the contrary movement of a stream current. *Second*, The *Stream Current*, which, as distinguished from the former, may be compared to an immense oceanic river, covering a space of two or three hundred miles in breadth, and reaching to a very great depth.

The velocity of these currents varies at different points of their course. The average amount in some of them is equal to sixty miles per diem; while, in particular places, the maximum reaches to 120 miles. Their temperature is either higher or lower than that of the adjoining sea, according to the heat of the climate in which they have their origin. This difference amounts to from 10° to 30° Fahrenheit. Some of these currents extend their course through an incredible space, producing an exchange of fluid over the most distant parts of the ocean, so that the water which in the Indian Sea washed the shores of Arabia and Southern Africa, is carried round the Cape of Good Hope and through the Atlantic to the shores of South and North America, the Azores, and even the coasts of Europe. These general remarks on currents, and the connected view of them which follows, will prepare the reader for the description of those represented on the Chart.

DESCRIPTION OF THE CHART.

I.—MEASUREMENTS.

The distances mentioned in the Chart are reckoned in nautical or geographical miles, 60 of which are equal to a degree of latitude. There are 69 statute miles to a degree; hence a nautical or geographical mile is about 6,086 English feet, while a statute mile is 5,280 English feet. A marine league is equal to three nautical miles. The temperature is uniformly stated in degrees and parts of Fahrenheit's scale, and the longitude is reckoned from the meridian of Greenwich.

II.—NAVIGATION OF THE ATLANTIC.

The various conditions of the Wind, a knowledge of which is necessary to a full understanding of sea tracks, will be found graphically represented in the Meteorological Division of our Atlas.[2] Next to these, the Ocean Currents are the most important elements in navigation, and, in proportion as our acquaintance with them has increased, the tracks which vessels ought to follow, in sailing from one country to another, have become better known, and more precisely fixed. The influence of ocean currents in navigation may be seen from the fact mentioned by Captain Sabine—that on his voyage from Sierra Leone to New York, he made almost a fourth part of the route by their assistance; of 2,000 miles through which he sailed, his ship was carried 1,000 miles by the currents. It is much to be desired that the numerous observations made on board the thousands of vessels which cross the Gulf Stream and other currents every year, were preserved and registered. From such a record the utmost benefit would be derived; for it is evident that more accurate information as to the extent, velocity, and temperature of these currents, would greatly tend to the more safe and speedy navigation of the Atlantic. In the year 1825, eight hundred sail of British shipping were lost at sea. And, upon an average, one American and two British ships are wrecked every day all the year round.[3]

1.—TRACKS FROM EUROPE TO NORTH AMERICA, &c.

Examples Coloured RED *on the Chart.*

Vessels sailing from Europe to the western coasts of North America, avoid the Gulf Stream, and steer along its northern border, between 40° and 50° north latitude; because it would create a delay of a fortnight if they were to enter and stem its current. Besides, on the northern route, the course of a vessel, on nearing the continent of America, is accelerated by the *Counter Current* which runs from Newfoundland to Cape Hatteras and Florida. If there be a long continuance of north-easterly or easterly winds outside of the zone of the passage-wind, the direction should be right across the ocean outside of the Azores. On this course, a vessel from the mouth of the Elbe reaches the harbour of New York, in favourable circumstances, in fifty days. The voyage is sometimes performed in forty days; but this mainly depends on getting rapidly through the English Channel with a fresh wind. A voyage of thirty days is reckoned one of extraordinary speed. Instances are on record of vessels from Cuxhaven having reached the Atlantic Ocean, beyond the Scilly Isles, in eighty hours; while, at the same time, it frequently happens that whole fleets of merchantmen are detained in the Channel for weeks together by contrary winds. The time occupied on the voyage between the ports of England and North America is stated on page 3.

The following voyages, extracted principally from the ships' journals of the Royal Prussian and Hanseatic Mercantile Marine, are selected as instances of extraordinary speed in sailing. A fast sailing ship can accomplish 200 miles a-day, and this may even be exceeded in very favourable winds. The average rate of sailing among the ancients, was thirty-five miles per diem. (See Rennel, *Geog.* of Herodotus.)

ENTIRE PASSAGES.				DAILY PROGRESS.			
Ships.	Sailed from	Arrived at	Days on Passage.	Ships.	Voyages.	Years.	Nautical Miles.
Charlotte.	Bremen, . . 1st May, 1836.	New York, . . . 24 June.	53	Mentor.	Round the World.	1833-4.	218
Charlotte.	Bremen, . . 3d " "	New York, . . . 31st May.	28	Enterprise (English Steamer).	First Steam Navigation in open Ocean.	1825.	236
Alexander.	The Weser, . 6th " "	. . . 24 June.	27	Princess Louise.	Round the World (second time).	1830-2.	219
Clementine.	Bremen.	Baltimore.	29	"	(third time).	1832-4.	222
				Sophia.	Hamburg to New York.	1828.	204

These are all rare examples of speedy sailing; the last-mentioned is the greatest we have seen recorded. The medium speed of a good sailer in a fresh wind, within the Passage-Zone, may perhaps be reckoned at from 140 to 160 nautical miles per diem.

If westerly winds prevail in the northern part of the Passage-Zone, which frequently happens, the voyager from the German Ocean to North America has to make a very unfavourable passage; being obliged, on leaving the English Channel, immediately to steer for lower latitudes, in order to avail himself of the north-east passage-wind. With the assistance of this, he sails till he has reached the meridian of the harbour for which he is bound, and then steers to the northward. He thus arrives at the place of his destination by a route which, though round about in regard to distance, is the shortest as respects time.

2.—TRACKS FROM EUROPE TO THE WEST INDIES AND THE PORTS OF SOUTH AMERICA.

Examples Coloured YELLOW *on the Chart.*

In sailing from European harbours to the West Indies, or the havens of Venezuela and the Gulf of Mexico, vessels direct their course to the south-west immediately on reaching the Atlantic Ocean, in order to arrive as soon as possible in the region of the north-east trade-wind. To accomplish this, they pass Madeira and the Canary Isles, and sail as far south as the latitude of 21° north, where they meet with the constant north-east trade. In this course navigators carefully avoid a too near approach to the coast of Africa, where, between the Capes of Nun and Blanco, the North African Current sets in towards the shore of the Sahara, and the danger it occasions is inc reased by the wind, which generally blows in shore. Numbers who expected, from their dead reckonings, to make the Island of Teneriffe, have been thus driven to the eastward and wrecked on these barren shores, where few could escape destruction. Having reached the zone of the above-named favourable wind, the voyager sails westward, and enters the Caribbean Sea between the Islands of Martinique and Trinidad.

If the voyage be directed to the Great Antilles, New Orleans, Vera Cruz, or Tampico, the course is through the channel which divides Guadaloupe from Antigua. This channel (latitude 16° 30′) forms almost invariably the great entrance to the Caribbean Sea, on the voyage to St Thomas, Puerto Rico, Port au Prince (Haiti), Kingston (Jamaica), the Havana, and the ports of the Mexican Gulf.

From Hamburg these ports are usually reached on the forty-second day, if the voyage be through the English Channel. But if the course from the mouth of the Elbe has been directed to the north-west, along the north side of the British Islands, which must be followed during contrary winds in the English Channel, then the voyage to the Antilles is lengthened by some days.

From Gundaloupe, the average time on the voyage is—to St Thomas, one and a-half to two days; Kingston, six days; the Havana, eighteen days; New Orleans, fifteen days; Vera Cruz, twenty-two to twenty-four days.

The voyage from Hamburg to Vera Cruz, the principal port of Mexico on the Atlantic coast, occupies from nine to ten weeks. Ships bound for La Guayra, Porto Cabello, Cartagena, or any of the other ports of Venezuela, usually enter the Caribbean Sea by the channel between the Islands of St Lucia and St Vincent. The voyages from Hamburg to La Guayra occupies, in general, sixty days.

Baron Humboldt was forty-seven days at sea, on the voyage from Coruña to Cumana; the Spanish ship, Pizarro, in which he sailed, entered the Caribbean Sea, as will be seen from her track on the Chart, by the north side of the Island of Tobago. The computed length of a voyage from England to the West Indies, including under that term the Bahama Islands and British Guiana, is ten weeks; and to any part of the continent of Central or South America, except the west coast thereof, and except British Guiana, twelve weeks.[4]

[1] Alluding to this, Mr Bellfield says, "In this instance [referring to a former paper] I have ascribed the currents of the ocean solely to the force of the winds, in compliance with the common theory—a view which I soon after found reason to abandon."—*American Journal of Science, &c.*, p. 290; 1843. The follow of this theory is most ably exposed, in a valuable paper on the Gulf Stream, by Lieutenant M. F. Maury, U.S.N.—*Ibid.*, xxvii., p. 161; 1844.

[2] Chart No. 5.

[3] American Journal of Science, xlvii., p. 100.—Lieutenant Maury suggests, that an inquiry into the habitat of certain fishes would help to elucidate the subject of the currents, as it is probable that they constitute the great highways through which migratory fishes travel from one region to another. The habitat of the whale makes it averse to the warm water of the Gulf Stream; and this fact led to the discovery of its temperature. Sea-nettles (*Medusæ*) constitute the chief food of the whale, and these are often met with in great quantities in the Gulf Stream, which conveys them to the Azores, the great place of resort for whaler and there "the Gulf of Mexico is the harvest-field, and the Gulf Stream the gleaner which collects the forage placed there, and conveys it thousands of miles to the hungry whale at sea."

[4] Passengers' Regulation Act.—2d Cadell's Comm. *Dict.*

TABLE OF THE VELOCITY OF THE GULF STREAM
in the different parts of the Strait of Florida & in all Months of the Year except January
According to Rennell & the Prussian Voyagers.

Months	From the entrance to the Narrows at Bemini I.			From the Narrows to the mouth in the Ocean			From the mouth to the parallel of 20°			Mean of all		Mean from the Narrows to Lat 37°
	Velocity in Geographical Miles 60-a Degree within 24 hours.											
	Number of Observations	Mean	Greatest	Number of Observations	Mean	Greatest	Number of Observations	Mean	Greatest	Number of Observations	Mean	Number of Observations	Mean
January										1	62		
February	1	52	52	52	1	72	72	72					
March	7	54.3	97	34	5	72.5	120	31	1	97	97	97	13	72	6	71
April	1	60	60	60	1	63	63	63	2	33.5	34	33	4	52.5	3	53.6
May	7	31.5	72	36	1	80 (Bauchelin)							7	31.5		
June	1	72	72	72	1	60	60	60					2	66	1	60
July	5	28.8	48	12	2	60	96	25	1	80	80	80	8	56.3	3	70
August	5	63	72	35	3	103	120	78	1	84	84	84	9	78.5	4	88
September	2	42.5	57	28					3	84.5	88	78	5	63.5	3	84
October	3	46	62	32	2	25	26	24	3	39.5	65	15	7	31	5	42
November	2	18	22	14	1	70	70	70					3	41	1	38
December	5	42.8	66	12	3	68	79	50	1	38	38	38	9	49	4	53

Table of the comparative mean Velocity of the Currents within 24 hours.

Gulf Stream	80	Nautical Miles
South Atlantic Current	15	"
Main Equatorial Current	60	"
Western Current of the Caribbean Sea	30	"
Gulf Stream in the Atlantic Ocean	35	"
Drift Current of the N.E. Trade Wind	10	"
North Atlantic Drift Current	(?) 10	"
Benguela Current	28	"
North African & Guinea Current	25	"
Brazil Current	20	"
Drift Current of the S.E. Trade Wind	10	"
Southern Connecting Current	(?) 15	"
Counter Current	30	"

CHART OF THE CURRENTS IN THE S.W. PART OF THE SOUTH ATLANTIC OCEAN AND AROUND CAPE HOORN.

Explanation of the Signs

Voyage of the Mentor 1823	Freycinet 1820	Freycinet 1820	
Princess Louise 1826	Cook 1774	Weddell 1823	
Dr in 1830	Lapérouse 1785	Beechey 1826	
Marchand 1796	Krusenstern 1803	Beechey 1828-29	
Dr in 1833	Lisianskoy	Foster 1828-29	
Christian 1822	Beaufort	Biscoe 1830-31	
Master K. Schooff 1825			

4.—TRACKS FROM AMERICA, &c., TO EUROPE.

Examples Coloured BLUE *on the Chart.*

On returning from North America to Europe, the voyager keeps to the north of the limits of the Gulf Stream; which is avoided, because experience has taught that the loss occasioned by the wear and tear of a vessel in navigating its stormy region is greater than can be compensated by the gain of time. But the general motion of the currents of the North Atlantic being from west to east, materially tends, in equally favourable circumstances of the wind, to shorten the return voyage to Europe.

Thus, if a voyage out from the mouth of the Elbe to the Havana requires fifty-nine days, forty-nine days are sufficient for the return.[1]

On the voyage from Cumana, La Guayra, or Porto Cabello to Europe, the voyager leaves the Caribbean Sea by the Mona Passage, between Haiti and Puerto Rico. He immediately afterwards steers in a north-easterly direction, so as to cut the parallel of 40° north between the meridians of 30° and 35° west. Vessels from the Virgin Isles to Europe also take this course.

From La Guayra to Hamburg, the voyage through the English Channel occupies fifty days. From St Thomas to Hamburg, the usual time is forty-five days. In the following instance, however, this voyage was accomplished in thirty-six days. The Prussian vessel, Elizabeth Louise, Captain Kasten, set sail from St Thomas on the 7th March, 1829, and anchored at Cuxhaven on the 12th April. This unusual speed was owing to the circumstance, that on the fourth day after sailing, in latitude 24° 33′ north, longitude 61° 9′ west, the passage-wind, which had blown from the east and east by south ceased, and westerly winds succeeded, which were only interrupted by easterly winds for four days, between latitudes 48° and 50° north, and longitude 17° west.

The voyager from Vera Cruz, Tampico, New Orleans, and the Havana, to Europe, sails through the Strait of Florida, immediately on leaving which, he steers to the north-east, in order to keep clear of the Gulf Stream. His course is now in an easterly direction across the Atlantic, south of Bermuda, crossing the Gulf Stream in the vicinity of the Azores.

The extract from the journal of the Kronprinz Von Preussen (*see ante, p.* 2), is given as an example of the return voyage from the West Indies to Europe. The Table contains observations on the state of the barometer and the temperature at noon each day.

On the return voyage from the South American ports, as from Monte Video or Rio de Janeiro to Europe, vessels keep near the coasts, in order to take advantage of the periodical and variable winds which there prevail. On crossing the Equator, they steer for the Azores, and sail as close with the north-east passage-wind as they did with the south-east passage in proceeding to the Southern Hemisphere. In coming from the Cape of Good Hope, the navigator, sailing with the south-east passage-wind to the Island of St Helena, and crossing the line at about 20° west, Greenwich, steers for the Azores, which are passed on the western side. Northwards from this, he falls into the great tracks from the West Indies to Europe.

5.—LINE AND STEAM PACKET NAVIGATION.

The following statistics of navigation are extracted from the *American Almanac* for 1841, in which numerous tables give the names and voyages of each packet belonging to the several lines during the year 1839. For a number of years past several regular lines of packet ships have been established and in operation between New York and Liverpool. The ships belonging to these lines are all New York or American vessels, and the steam ships which have hitherto passed between England and New York are all English vessels.

LINE PACKET NAVIGATION BETWEEN LIVERPOOL AND NEW YORK.

Name.	Voyage.	Outward.				Homeward.			
		No. of Passages.	Longest.	Shortest.	Average of all.	No. of Passages.	Longest.	Shortest.	Average of all.
			No. of Days.	No. of Days.	No. of Days.		No. of Days.	No. of Days.	No. of Days.
Old or Black Ball Line	Liverpool and New York.	24	48	22	33¾	24	36	18	22¼
Dramatic Line	" "	12	38	23	30½	12	25	17	20¼
Star Line	" "	11	45	27		11	28	21	24
Swallow-Tail Line	" "	12	45	28	35	12	31	17	22½

STEAM SHIP NAVIGATION BETWEEN ENGLAND AND AMERICA.

The steam packet ship Sirius left Cork, in Ireland, on the 4th of April 1838; and the steam packet ship Great Western left Bristol, in England, on the 8th of the same month; and they both arrived at New York on the 23d of April. This event formed a new era in navigation, and was the commencement of a novel and expeditious mode of intercourse between England and the United States.

Name.	Voyage.	Outward.				Homeward.			
		No. of Passages.	Longest.	Shortest.	Average of all.	No. of Passages.	Longest.	Shortest.	Average of all.
			No. of Days.	No. of Days.	No. of Days.		No. of Days.	No. of Days.	No. of Days.
Great Western	Bristol and New York.	13	21½	13	16	12	15	12	13½
Royal William	Liverpool and New York.	3	21½	18½	20		17½	14½	15½
Liverpool	Liverpool and New York.	7	18½	16	17		17½	13½	15
British Queen	Portsmouth and New York.	6	20½	14	17½		22½	13½	16

Mr Redfield of New York has furnished the following interesting details, showing the

COMPARATIVE SAFETY OF STEAM NAVIGATION.

Voyages of Steam Vessels connected with the port of New York.	Miles Navigated.	Number of Passengers.	Number of Accidents.	Lives Lost.	Proportion of do. to No. of Passengers.
For 5 years, ending 31st December 1824	2,827,750	4,796,000	12	38	1 in 126,211
" December 1833	4,210,200	9,419,700	5	62	1 in 151,931
" 31st December 1838	5,467,450	13,886,300	2	8	1 in 1,985,787

The average number of miles to each explosion, for the three periods, was, for the first period, 235,646; second, 843,240; third, 2,733,725.
The estimated average pressure of steam used during the first period, was 7 inches; second period, 14 inches; third period, 18 inches.

It appears, from the average results of this Table, that during even the first period of five years after the navigation was thrown open to public competition, the ratio of steam accidents was only equal to 1 for more than 20,000 trips or voyages; and that the average loss of life was only equal to 1 for more than 126,000 passengers exposed. Thus, at the fair outset of this noble enterprise, a degree of safety was attained for the passengers such as may well challenge comparison with any artificial means of transit or locomotion that have ever been resorted to by the human race.

III.—CURRENTS.

The *Southern Atlantic Current*, as described by Rennel, is "the first link of the stupendous chain which, by the aid of adjunct waters collected in its progress, becomes the *prime mover* in the great machine." It is a continuation of the Mozambique Current, which, running between the eastern coast of Africa and the Island of Madagascar, doubles the Cape of Good Hope round the Bank of Agulhas, and enters the Atlantic Ocean by the *Cape* or *Agulhas Current*. Thence, under the name of the *Southern Atlantic Current*, it flows, in a north-easterly direction, along the western coast of Africa to the parallel of St Helena, whence its course is more easterly, till it is turned to the westward by the form of the coast and the opposition of the *Guinea Current* from the north. It now forms the commencement of the *Equatorial Current*, which stretches across the Atlantic on both sides of the Equator, till it has reached the middle point between Africa and South America, when it sends off the *North-West Branch Current*, and, on approaching Cape St Roque, it subdivides—the main current passing by the north towards the West Indies, and the other southwards along the eastern coast of South America, forming the *Brazil Current*. The main stream continues its course to the Caribbean Sea, which it enters by the *Guyana Current*. From the Gulf of Mexico the *Gulf Stream* passes along the coast of North America and across the Atlantic Ocean to the Azores, where, having turned to the southward, it mixes with the *South Africa* and *Guinea Current*, which again meets the stream ascending from the south, and thus maintains a perpetual circulation.

Rennel's Current commences near Cape Finisterre, and, running along the shore of the Bay of Biscay, crosses the English Channel, touching on its eastern border the Scilly Isles. Thence passing Cape Clear, it enters the ocean, and, turning towards the south, re-unites with the North African Current.

The Gulf Stream is joined by the *Arctic* and *Hudson Bay Currents*, on the east of the Bank of Newfoundland. These—the former of which originates beneath the Polar Ice—bring down to southern latitudes those immense icebergs and fields of ice, which, though generally dissolved by the warm water of the Gulf Stream, prove often so formidable to mariners. The *Southern Connecting Current*, detaching itself from the Brazil Current, stretches across the Atlantic from west to east. It passes to the southward of the Cape of Good Hope, at the distance of 150 miles outside of the Cape Current, and traces of it are found in the Indian Ocean, 2,000 miles beyond the Cape.

Cape Horn Current.—This current flows from the Pacific Ocean, round the southern extremity of America, towards the north-east, and is supposed to communicate with the southern connecting current.

1.—DRIFT CURRENTS.

The Drift Currents, which owe their origin to a *perpetual* wind, are constant, running always in the same direction, and generally with a nearly equal velocity. These are found in the Atlantic, between the Tropics, and are caused by the trade-winds; but they are considered steady only between the parallels of 23° north and 9° south latitude, within which space the trade-winds regularly blow. In the region of calms the Drift Current is very weak; its mean velocity is from nine to ten miles per day.

Those Drift Currents which are produced by *prevailing* winds are not so constant, neither do they always run in the same direction nor with like velocity. They prevail to the north and south of the parallel of thirty degrees.

2.—EFFECTS PRODUCED BY THE MOTION OF THE CURRENTS.

Speaking of the motion of the water of the Atlantic, between the parallels of 11° and 43° north, Humboldt says: "From our present knowledge of the rapidity of currents, we may estimate that, supposing a molecule of water to return to the same place from which it departed, it would require a period of 180 years and ten months to complete the circuit of 3,800 leagues. A boat, which may be supposed to receive no impulse from the winds, would require thirteen months from the Canary Islands to reach Caracas [on the coast of Venezuela]; ten months to make the tour of the Gulf of Mexico, and reach Tortoise Shoals, opposite Havana; while forty or fifty days might be sufficient to carry it from the Strait of Florida to the Bank of Newfoundland." At a time when the art of navigation was in its infancy, the Gulf Stream furnished the genius of Christopher Columbus with certain indications of the existence of western regions. Two corpses, the features of which indicated a race of unknown men, were thrown on the coast of the Azores, towards the end of the fifteenth century. Nearly at the same period the brother-in-law of Columbus, Pedro Correa, governor of Porto Santo, found on the strand of this island pieces of bamboo of an extraordinary size, brought thither by the western currents.[2] When the wind has been long from the west, a branch of the Gulf Stream runs with considerable force in a north-easterly direction, towards the coasts of Europe. By this the fruit of trees belonging to the Torrid Zone of America is annually cast ashore on the western coasts of Ireland and Norway. And Pennant observes, that the seeds of plants which grow in Jamaica, Cuba, and the adjacent continent, are collected on the shores of the Hebrides. Thither, also, barrels of French wine, the remains of vessels wrecked in the West Indian Seas, are carried.[3] In 1809, H.M.S. Little Belt was dismasted at Halifax, Nova Scotia, and her bowsprit was found eighteen months after (11th February 1811), in the Basque Roads [4] and the mainmast of the Tilbury, burnt off Hispaniola, in the seven years' war, was brought to our shores.[5] Thus Humboldt observes: "The currents of the ocean supply new and most abundant matter of research for the elucidation of the physical phenomena of the earth. While they carry the temperature of one zone into that of another, they sometimes promote and sometimes retard the distribution of the race of men, and the commercial intercourse of civilized nations."—"It is the duty of philosophers to determine and adjust their numerous elements, according to the sublime model of astronomical science, in order that some of those eternal laws may be made known by which the climatic changes of the firmament are dependent on the liquid and aerial currents of our planet."[6]

[1] The ship Frederich Wilhelm III. made the voyage from New Orleans to Cuxhaven, during summer 1830, in thirty eight days; and the Mentor sailed from New York to Cuxhaven, in February and March 1837, in twenty-six days; the same time that was occupied by the Netherlands steam ship, Curaçoa, on the voyage from Rotterdam to Surinam. See this track on the Chart, with the daily progress of the vessel.

[2] Marmol, Hist. del Nuevo Mundo, ii., p. 14.

[3] Purdy's Atlantic Memoir.

[4] A. Von Humboldt's Manuscript Memoir on Ocean Currents, kindly communicated to the author. Berghaus' Länder und Völkerkunde, iv. p. 651.

[5] Nacken, View of the Hebrides.

[6] Horsburgh, 534.

The following Table, being an abstract from the journal of the ship Crown Prince of Prussia, shows the course followed on the voyage from Hamburg to the Havana, and will serve as an example of the great trade routes between Europe and the West Indies:—

VOYAGE OF THE ROYAL PRUSSIAN SHIP KRONPRINZ VON PREUSSEN FROM HAMBURG TO THE HAVANA.

The positions marked by an asterisk (*) are according to reckoning—all the others according to observation. The longitude by chronometer.

Day of Year.	Date. 1835 and 1836.	General Course.	Distance in Nautical Miles.	Position at Mid-day. Latitude North.	Longitude from Greenwich.	Wind.	Weather.	Remarks.
1	November 19	N. 74° W.	62	54° 17′	6° 21′ E.	S. and SSW.	Good	On the 17th, at 10 P.M., Heligoland Light NE. and N., one mile distant.—South Foreland, at 12½ P.M., NNW., one and a-half mile distant.
2	" 20	S. 51 W.	77	54 23	4 24	SW., S., ESE.	"	
3	" 21	S. 37 W.	146	51 25	2 18 *	ESE., S.	"	
4	" 22		78	In the English Channel.		SSE., S., E.	"	
5	" 23	S. 64 W.	174	49° 58′ *	2° 46′ W.	E. by N.	Rainy	
6	" 24	S. 61 W.	183	48 30 *	6 46 *	E. by N., E.	Cloudy	
7	" 25	S. 47 W.	108	48 25 *	9 48 *	ESE., SW.	Good	
8	" 26	S. 42 W.	163	47 12	11 38	W., ESE., E.	Changeable	
9	" 27	S. 42 W.	106	47 51 *	14 23 *	ENE.	Cloudy	
10	" 28	S. 44 W.	158	49 38	16 55	NE., NNW., N.	"	
11	" 29	S. 12 W.	130	50 31 *	17 32 *	NW.	Rainy	
12	" 30	S. 60 W.	41	50 1	18 12½	NW., W., SW.	Rain	
13	December 1	S. 42 W.	69	57 1¼ *	19 12	SSW. to E.	Changeable	
14	" 2	S. 42 W.	131	53 42	23 58	E., ESE., S. by E.	Variable	
15	" 3	S. 32 W.	109	54 4 *	23 28 *	SE., S.	"	
16	" 4	S. 30 W.	130	52 39	25 44½	S., SE., E., ENE.	"	
17	" 5	S. 48 W.	162	50 37	27 55½	NE.	Good	
18	" 6	S. 43 W.	93	49 22	28 52	N., NNW.	"	
19	" 7	S. 56 W.	103	48 31	30 32	N., E., SE.	Rain—Variable	
20	" 8	S. 63 W.	65	48 15	31 28 *	ESE., WSW.	Good.	
21	" 9	S. 37 W.	58	47 29	32 16	S., NW.	"	
22	" 10	S. 41 W.	102	46 7	33 7	N., N. by W.	"	
23	" 11	S. 61 W.	34	45 47	33 33	N., ESE.	"	
24	" 12	S. 61 W.	90	45 6	33 0 *	E. by N., ENE.	"	
25	" 13	S. 62 W.	113	44 18	36 30½	N., ENE., NE.	"	
26	" 14	S. 62 W.	59	43 51	38 23½	E., E. by S., ENE.	"	
27	" 15	S. 63 W.	122	43 29 *	40 51 *	E. by N.	Variable	
28	" 16	S. 53 W.	132	42 1	43 31½	E. by N.	Good	On the 28th, at 8 P.M., the Island Desiderada, was S., distant five and a-half miles, whence the reckoning was begun.
29	" 17	S. 71 W.	104	41 29	44 28½	E., ENE., NE.	"	
30	" 18	S. 51 W.	127	40 44	46 37	E., ENE., SE.	"	
31	" 19	N. 84 W.	154	41 10	48 46½	S., SW., W.	Variable—Rain	On the 29th, at 5 A.M., Montserrat was N. one and a-half mile distant.
32	" 20	S. 8 W.	104	43 38	49 4½	W.	Good	
33	" 21	S. 8 W.	119	45 51	49 11	W., WSW.	"	
34	" 22	S. 8 W.	51	46 39	49 30½	W., WNW., SW.	Changeable	
35	" 23	S. 77 W.	37	46 9	49 59	NNW., N.	Good	
36	" 24	S. 4 W.	88	47 29	50 7½	W., WNW.	Changeable	
37	" 25	N. 79 W.	73	47 41	51 30½	NW., N. by W.	Good	
38	" 26	S. 88 W.	102	47 29	54 0	NNE., NE.	"	
39	" 27	S. 78 W.	142	46 58	56 37½	ENE., E., ESE.	"	
40	" 28	S. 61 W.	142	46 34	58 56	ESE., ENE.	"	
41	" 29	W.	140	46 39	61 37	ENE.	"	
42	" 30	N. 87 W.	139	46 52	64 53	E. by N.	"	
43	" 31	N. 87 W.	145	46 37	67 26½	ESE.	"	
44	" 31	N. 87 W.	130	46 46 *	70 2 *	E., NE., N.	"	
45	January 1	N. 74 W.	104	47 23	72 21½	ENE.	Variable	At 8 P.M. Haiti was seen.
46	" 2	N. 72 W.	80	47 41	74 39	E., N.	Good	
47	" 3	S. 66 W.	76	48 29	76 38	NW., ENE.	"	Navassa, N. five and one-third miles.
48	" 4	N. 63 W.	128	49 58	78 57	ENE., NE.	"	Jamaica in sight.
49	" 5	N. 76 W.	126	49 0	79 34	ENE., NE.	"	Cape Montego at 6 P.M.
50	" 6	S. 86 W.	78	49 29	80 12½	NNE.	"	Little Cayman.
51	" 7	N. 62 W.	150	50 43	83 34	NE. by N., ENE.	"	
52	" 8	N. 48 W.	86	51 49	84 12	E., S., SW., W.	"	Cuba in Sight.
53	" 9	S. 81 W.	50	51 32	85 39½	NW., N.	"	
54	" 10	N. 51 W.	69	52 43	85 57	N., NE.	"	Cape Antonia NNE., distant three miles.
55	" 11	N. 17 W.	54	54 19	86 16	NE., ENE.	"	
56	" 12	N. 62 W.	69	55 9	88 58½	ESE., NE., S.	Changeable	
57	" 13	"	43	55 39	89 49	SSW., N., SE.	Good	
58	" 14	S. 77 E.	44	55 20	93 21½	SE. SW.	"	
59	" 15	" "	39	" "	" "	" "	"	At 9 P.M. came to anchor in the Harbour of Havana.

Navigation within the Antilles, from west to east, is attended with great difficulty, on account of the opposition of the passage-winds and the currents. In one case, a ship occupied eleven days in sailing from Kingston, on the south side of Jamaica, to Port Maria on the north side. A ship bound from Jamaica to the little Antilles, cannot make the voyage within the Caribbean Sea, along the south side of Haiti, but must steer through the windward passage, and along the south-east of the Bahama Isles into the ocean, and then take a northerly course to the Tropic of Cancer, or even to the parallel of 25° north, whence the course is directed southwards. On this voyage, from west to east, almost as many weeks are required as days in an opposite direction.

If the voyage from the Canary Isles to the Leeward Antilles, Guadaloupe, and Antigua, occupies from eighteen to twenty days, and that from Teneriffe to Cumana, can be accomplished in twenty-two days, the voyage from Kingston, in Jamaica, to the Danish Island of St Thomas, will require twenty-five days; although in the latter case the direct distance is only 680 miles, whilst in the former the whole breadth of the Atlantic Ocean has to be passed over.

3.—TRACKS FROM EUROPE TO THE COUNTRIES IN THE SOUTHERN HEMISPHERE.

Examples Coloured RED *on the Chart.*

The late Mr Meyen, who has recently collected much valuable information on the trade routes through the Southern Atlantic, says, that on leaving the English Channel the course is almost invariably directed to the south-south-west, the first point to be reached being the Canary Isles, in the vicinity of which the north-east passage-winds usually commence. The prevailing winds, from the mouth of the Channel to this place, are either west or west by south, or north and north-west; they seldom blow from any other point. With these winds it is easy to attain the region of the north-east passage-winds; which, however, are always more unsteady the nearer we approach the Equator. In sailing with the north-east passage, it is necessary to keep as far to the eastward as the wind will permit, in order that the line of the Equator may be cut as far as possible in this direction. Hornburgh recommends the space between the meridians of 18° and 23° west. Arrived in the region of the south-east passage-wind, it is necessary to sail as close to it as its direction will permit; this is usually south-west by south. In this manner the voyager arrives at Brazil, under the line of Cape St Augustine, whence the coast can be navigated in any direction.

The voyage from Hamburg to Rio de Janeiro may be performed in from fifty to sixty days, although it is often much longer. The speed of a passage depends as much on the condition of the vessel as on the regularity of the winds. The ship Christian, Captain Rinck, made the voyage from Hamburg to Monte Video, during winter 1826-27, in fifty-five days; while the Kronprinz Von Preussen, Captain Stewart, required for the same voyage, without any extraordinary interruption, from May to August 1835—seventy-five days. Ships bound from Europe to the Cape of Good Hope and India, follow the above course to the Equator, they then steer for the rocky Island of Trinidad, in order to avail themselves as much as possible of the south-east passage-wind; and passing this island on the western side, they sail with the western winds and easterly currents towards the south point of Africa, so as to cut the parallel of 30° south somewhere about longitude 20° west. On this route Captain Horsburgh made the voyage from the western entrance of the English Channel to the Cape of Good Hope in fifty-nine days.*

VOYAGE OF THE KRONPRINZ VON PREUSSEN FROM THE HAVANA TO HAMBURG. (*Referred to p.* 3.)

The positions marked with an asterisk (*) are according to reckoning—all the others from observation. The longitude by the chronometer.

Day of Year.	Date. 1835.	General Course.	Distance in Nautical Miles.	Position at Mid-day. Latitude.	Longitude from Greenwich.	Wind.	Weather.	Remarks.
1	February 15	N. 84° E.	78	24° 2′ N.	81° 12′ W.*	Changeable, E. and W.	Good.	Morro Castle, Havana, point of departure, in lat. 23° 9′, long. 82° 23′ W.—Ther. F. 80° 66.
2	" 16	N. 89 E.	103	25 21	79 39	W., SSE.	Changeable	
3	" 17	N. 3 E.	408	26 58	79 46½	W., WNW.	Good	
4	" 18	N. 8 E.	102	28 47	79 50½	NNE., NNW.	"	On the 4th day left the Gulf Stream, which hitherto had run due N., with a velocity of 3 miles an hour.—Ther. F. 68.°
5	" 19	N. 17 E.	96	29 41	79 59	NNE., N.	"	
6	" 20	N. 12 E.	94	30 37	77 44½	ENE., E., E. by S.	"	
7	" 21	N. 69 E.	113	31 32	75 47	SE. by S., S.	Variable	Bar. 30.061 Ther. 66° 92
8	" 22	N. 69 E.	151	32 30½	73 6½	S., SSE., S. by W.	Good	" 29.992 " 64 94
9	" 23	N. 69 E.	169	33 50	70 1	S. by W., SSW.	"	" 29.892 " 64 94
10	" 24	N. 69 E.	128	34 54	67 30½	SW., WSW., NE.	Cloudy	" 29.797 " 66 74
11	" 25	N. 66 E.	45	34 54	66 38½	Calm. NNW., W.	Variable	" 29.900 " 65 84
12	" 26	N. 66 E.	129	35 57	63 58	W., S., S. by E.	Good	" 29.997 " 64 76
13	" 27	N. 71 E.	103	36 50*	62 22*	S.	"	" 29.895 " 63 86
14	" 28	N. 86 E.	145	37 19	57 11½	WSW., W.	Good	
15	March 1	N. 79 E.	126	37 44*	54 34*	WSW., W., S.	Changeable	Still stormy—sea raging
16	" 2	N. 70 E.	69	38 7	53 11*	W., SW.	Good	Bar. 29 20
17	" 3	N. 77 E.	121	38 34*	50 41*	S. by E., W., NE.	Rain—stormy	" 29.689 " 62 96
18	" 4	N. 85 E.	84	38 39*	49 12*	NE., S., SSW., N.	Changeable	" 29.387 " 62 96
19	" 5	N. 85 E.	65	38 54	48 5½	NNE., E.	Cloudy	
20	" 6	N. 56 E.	129	39 97	46 3½	E. by S., SSW.	Variable	" 29.602 " 64 94
21	" 7	N. 59 E.	49	39 30*	45 9*	WSW., NN., S.	Changeable	" 29.495 " 59 84
22	" 8	N. 47 E.	160	41 19*	43 37*	SW.	"	" 29.396
23	" 9	N. 65 E.	154	42 25*	39 7*	SW., NNW., N.	Rainy	Stormy " 55 94
24	" 10	N. 87 E.	91	42 55	36 59	NW., E., ESE.	Changeable	" 55 76
25	" 11	N. 86 E.	146	44 22	36 38½	SE., S., SW.	Rain	" 54 86
26	" 12	N. 87 E.	170	45 8	32 44*	WSW., W.	Changeable	" 29.797 " 59 90
27	" 13	N. 79 E.	109	45 31	30 16*	W., NNE.	"	" 29.797 " 53 96
28	" 14	N. 87 E.	88	46 5	28 19*	NW., N., SSE.	Good	" 51 98
29	" 15	N. 72 E.	87	46 53	25 50½	SE., WSW., W.	Changeable	
30	" 16	N. 83 E.	77	46 57	23 58½	WSW., N., E. by S.	"	" 57 02
31	" 17	N. 81 E.	121	47 33	20 56	S., SW.	"	" 29.797 " 59 90
32	" 18	N. 79 E.	123	48 16	18 31	SW., W. by S.	Good	" 59 98
33	" 19	N. 79 E.	141	49 16	15 23½	SW. by W.	Variable	" 57 92
34	" 20	N. 78 E.	88	49 36	13 5½	SW. by W.	Good	" 57 02
35	" 21	N. 88 E.	61	49 30	8 29	NNE.	"	" 54 86
36	" 22	N. 89 E.	39	49 47	7 40	ESE.	Variable	" 52 58
37	" 23	S. 84 E.	31	49 42	6 35½	E., ESE.	"	" 50 00
38	" 24	S. 83 E.	29	49 17	6 20½	E., E. by N.	Cloudy	At 11 A.M. the Light-House of St Agnes north-half-west, 4 miles distant.—Ther. 50° F.
39	" 25	S. 83 E.	31	49 29	6 7½	E., ENE., E.	"	
40	" 26	S. 84 E.	41	49 32*	5 4*	E. by N., ESE.	"	At 3 A.M. Cape Lizard, NNW., 1 mile distant.
41	" 27	S. 89 E.	35	50 5*	4 29*	SE. by E., ESE.	Variable	Eddystone at 12 noon, NNE., ¾ mile distant.
42	" 28	S. 89 E.	27	50 7	3 47*	E. by S.	Lowering	
43	" 29	S. 68 E.	35	49 56	3 37½	SE., S.	Variable	South Foreland Light, at 1 A.M., NNW., 1¼ mile distant. E. inclus.
44	" 30	N. 77 E.	119	50 17	0 24*	S., SSW.	Good	
45	" 31	N. 85 E.	63	50 34*	2 23 E*	WSW.	Variable	At noon, Bar. 30.001 Ther. 50° 90
46	April 1	N. 83 E.	143	53 38	5 11*	SSW., WSW.	Good	" 30.001 " 52 16
47	" 2	N. 54 E.	49	54 7*	6 19*	W., S., E., ENE.	"	Rainy " 50 00
48	" 3	Near the mouth of the Elbe.				NE.		
49	" 4	In the Harbour of Cuxhafen.						

* See the Chart, on which this track is given from the Equator to the Indian Ocean, marking the position of the ship each day at noon, from the 21st May to the 2d July 1862.—The usual time from the English Channel to the Cape is seventy days.—The steam ship Enterprise, on the first attempt to perform the voyage from England to India by steam power, was thirty-three days between Falmouth and St Thomas, in the Gulf of Guinea; thence to the Cape of Good Hope, twenty-two and a quarter days; in all, 105 days and a quarter days to the Cape. But on this occasion steam power was only partially used.

4.—TRACK BOTTLES.

Bottles containing a statement of the position of the ship, and date of immersion when sent adfoat on the ocean, are of considerable value in indicating the general direction of *surface* currents. It will be seen, from the direction of those in the Chart, that the waters of the Atlantic, south of 45° north latitude, have a tendency to move towards the Gulf of Mexico. Whether these bottles were cast in near the shores of Europe or in the middle of the ocean, they have generally been found among the West India Islands. On the contrary, those which were immersed on the north of latitude 45° were carried to the coasts of Europe. The surface waters of the North Atlantic and Davis Strait, driven by the prevailing winds, have a tendency to run in an easterly direction till, between the meridian of 50° and 40° west, they appear to spread in a fan-like form northward to Iceland, and southward to the Canary Islands. The following examples are marked on the Chart:—"*Hecla*," Captain Parry.—1. A bottle was thrown from H.M.S. Hecla, Captain Parry, in latitude 56° 36′ north, longitude 23° 45′ west, on 13th October 1820, and found on the south coast of Iceland on the 6th or 7th March 1821. This indicates the northerly drifts of the Atlantic Head during the winter season, and corroborates the common opinion, that although, in early summer, the currents here are generally prevalent to the south and south-west, yet that they have a contrary direction in the other parts of the year.[36] 2. A bottle was cast from H.M.S. Hecla, Captain Parry, in latitude 53° 13′ north, longitude 46° 55′ west, 16th June 1819, and found on the south-east shore of Teneriffe, 29th July 1821. The straight lines on the Chart, of course, can only show the *shortest* distance through which these have travelled, from the time they were thrown out till they were picked up, and can give no direct information as to the course of the currents or drifts by which they may have been propelled.

IV.—TEMPERATURE AND OCEANIC WARMTH EQUATOR.

The mean of all the observations instituted by Humboldt, show that the temperature of the surface of the Atlantic Ocean is invariably higher than the mean temperature of the atmosphere.

In the warm zone of the North Atlantic, the maximum of the sea between latitude 16° 20′, and 11° north, was 72·50 to 78·44, whilst that of the air amounted to 71·6, and 77·11 to 77·9.

Peron, from the mean of observations made four times a-day, came to the same conclusion, and found no exception to the rule in the zone between latitude 49° north and 45° so.th.

The same result appears from the numerous and highly accurate observations of Meyen, during the second circumnavigation of the Princess Louise, and in those of Captain Fitzroy, in the surveying voyages of the Beagle. But against these we must place the observations of Irving and Forster, with those more recently made by Kotzebue, from which the temperature of the atmosphere appears to be higher than that of the sea; a result which I find fully confirmed in the warm zone of the Atlantic and beyond it, between latitudes 35° north and 20° south; whilst in the temperate zone the sea is warmer than the air. The temperature of sea and air, however, are so nearly equal, that the difference amounts at most to 1° 18; and thence it is apparently of little importance whether the temperature of the one or the other be measured.[37] See following Table of comparative temperature of the air and sea.

The temperature of the sea, as well as that of the atmosphere, is dependent on the season of the year and the hour of the day at which the observation is made. The depth of the sea has a great influence on the temperature of its surface; for the immense body of water contained in the ocean preserves its heat; whereas, a thin stratum of water very soon acquires the colder temperature of the surface. This was verified by the experiments of Dr John Davy, who, on approaching the land of Table Bay, Cape of Good Hope, from the westward, found the temperature of the sea reduced 2°; and the same observation was made on approaching the Island of Ceylon, although the bank of soundings does not extend far out from either of these places.[38] In calm and settled weather, Dr John Davy found that the temperature of the sea reached its maximum about one or two hours after noon, and its minimum about sunrise. Peron found the temperature of the sea at mid-day invariably somewhat lower than that of the atmosphere; at midnight it was invariably higher, whilst at morning and evening they were equal. The temperature of the atmosphere, as well as that of the ocean, increases regularly on approaching the Caribbean Sea from the shores of Europe and Africa. It is well known that all inland seas have a higher temperature than the open ocean under equal parallels; and besides the effect of heat communicated from the surrounding countries, the high temperature of the Caribbean Sea is greatly owing to the currents of warm water which enter it from the hot zone of the North Atlantic.

The following observations of Humboldt, on his voyage from Coruña to Cumana, show this increase in the temperature of the sea:—

Latitude North.	Longitude West.	Temperature of the Ocean on the Surface.	Latitude North.	Longitude West.	Temperature of the Ocean on the Surface.
39° 10′	16° 18′	59° 00	20° 8′	28° 51′	70° 16
34 30	16 55	61 34	17 57	33 14	72 32
32 16	17 4	63 86	14 57	44 40	74 66
30 36	16 54	65 48	13 51	49 43	76 46
29 18	16 40	66 74	10 46	60 54	78 44
26 51	19 13	68 00			

The result of these, and many other observations made on board the vessels of the Prussian Mercantile Marine, show that the temperature increases 0° 45 for every degree of longitude in approaching the Caribbean Sea from the meridian of 45° west.

The temperature of the Atlantic Ocean has been measured by numerous voyagers, under all parallels, in both Hemispheres. In the following Table we give the mean results of all these, to which we have added, for the sake of comparison, that of the atmosphere.

MEAN TEMPERATURE OF THE ATLANTIC OCEAN IN DIFFERENT DEGREES OF LATITUDE.

	Latitude.	Sea.	Atmosphere.	Sea warmer or colder than the Air. + Warmer. — Colder.		Latitude.	Sea.	Atmosphere.	Sea warmer or colder than the Air. + Warmer. — Colder.
North Atlantic.	55° N.	49.64	48.56	+ 1.08	South Atlantic.	50° S.	78.44	79.52	— 1.08
	50	53.96	51.08	+ 2.88		10	77.72	78.80	— 1.08
	45	57.74	56.54	+ 0.00		15	76.10	76.82	— 0.72
	40	62.24	61.88	+ 0.36		20	73.58	73.02	— 1.44
	35	68.92	68.00	+ 1.08		25	71.60	70.52	+ 1.08
	30	69.08	72.86	— 3.06		30	69.26	69.08	+ 0.18
	25	71.78	75.38	— 3.50		35	64.40	62.24	+ 2.16
	20	74.30	77.18	— 2.88		40	58.64	57.74	+ 0.90
	15	75.10	78.62	— 3.52		45	52.52	47.66	+ 4.86
	10	78.26	79.70	— 1.44		50	48.92	44.24	+ 3.78
	5 N.	80.24	80.24	0. 0		55 S.	41.00	39.38	+ 1.62
	Equator.	78.98	80.06	— 1.08					

The result of numerous observations[39] shows that the line of maximum temperature of the atmosphere in the Atlantic Ocean does not correspond with that of the Terrestrial Equator;[40] and such also we find to be the case in regard to the water—the line of greatest warmth of which is found to be invariably on the north side of the Equator. The following Table furnishes the observations whence this result is deduced:—

POSITION AND TEMPERATURE OF THE LINE OF GREATEST HEAT IN THE ATLANTIC OCEAN.

Month.	Observer.	Parallel.	Temperature.	Mean Parallel.	Mean Temperature.
January	Harmssen (1823)	1° 40′ N.	80° 96°	3° 13′ N.	81° 26′
	Rodbertus (1838)	4 42	82 84		
February	Meyen	0 0	81 32	1 20	83 21
	Wendt	2 36 N.	85 10		
March	Perrins	0 15 N.	83 48	1 32	82 17
	Davy	3 30	81 50		
April	Quevedo	2 10 S.	83 53	0 23	83 83
	Livingston	3 19 N.	84 02		
	Krusenstern	0 65.	84 03		
May	Kotzebue	3 6 N.	84 56	3 60	82 23
	Davy	2 48	82 22		
June	Dalrymple	2 30 N.	79 88	5 29	83 22
	Abercrombie	8 55	83 68		
	Harmssen (1826)	3 42	83 39		
	Do. (1829)	6 27	82 22		
July	Harmssen (1824)	7 50 N.	83 39	6 10	84 29
	Siewert	4 30	85 10		
August	Yoo	...	...	1 40	80 96
September	Duperry			6 58	80 42
October	Chamisso	6 0 N.	83 66	7 30	82 84
	Bobmann	6 0	83 84		
	Lamarche	10 0	84 38		
	Meyen	8 0	83 48		
November	Block	...	...	3 09	84 92
December	Siewert	...	...	5 20	82 4
	Mean of the Year,	. . . .		3 30 N.	82 68

The position of the Oceanic Warmth Equator, in the middle of the Atlantic Ocean, is thus found to be latitude 3° 30′ north; and its mean temperature 82° 8, as represented on the Chart.

From all these observations, we are inclined to believe that the zone of warmest water in the Atlantic Ocean does not vary according to the sun's declination; or, in other words, that the position of the maximum line of ocean warmth does not depend on the period of the year[41]—that, on the contrary, this zone will be found invariably on the north side of the Equator; and that the observations of Quevedo, who alone found the warmest water on the south side of the Line, is an exception to the rule. This state of the ocean is mainly attributable to the Southern Atlantic Current, which brings cold water from the south to the vicinity of the Equator, reducing its temperature; whilst, in the parallel of 3° 32′ north, the sea is proportionally free from currents, which permits the concentration of heat. To this may be added the peculiar form of the basin of the sea; in this parallel the coast of Africa extends far to the westwards, and the heated air of the interior, which here reaches its maximum temperature, is carried by the trade-winds across this part of the ocean.

V.—FUCUS BANKS.

In the middle of the Atlantic, the Sargaço Sea[42] occupies the eddy, or whirl caused by the revolution of the currents. The weed from which this sea has its name covers the surface of the ocean, for a space extending from the meridian of 20° westwards to the Bahama Islands, between the parallels of 20° and 45° north. In many places it is so thickly matted over the surface as greatly to retard the progress of vessels passing through it. The quantity of weed is really astonishing. "In the space pointed out," says Humboldt, "we have an extent of surface, the greater part of which is covered with sea-weed, equal to more than 240,000 square miles—almost six times as large as Germany."[43]

[36] Horsburgh.
[37] Berghaus' Länder und Völkerkunde, 1 band., § 459, where this subject is treated at great length.
[38] Horsburgh's East India Directory. i., p. 16, edit. 1841; and Humboldt's Memoir.
[39] These observations are given at great length in Berghaus' Länder und Völkerkunde, i., ch. 12. The most copious are those of the officers of the Prussian Mercantile Marine, which, he says, may be thoroughly depended upon, as the ships were furnished with most valuable and accurate instruments, through the care of the President of the Seehandlungs Institute.—[J.]
[40] See Meteorological Division of Physical Atlas, Chart i.
[41] Humboldt Relat. Historique, i., p. 224, edit. in 2 vols; Klimtz Meteorologie, ii., p. 115.
[42] So called by the early Spanish and Portuguese navigators, from the immense quantity of sea-weed found in it (Sargasso, Sp.—sea lentils). It is of a beautiful green colour, hence the early Dutch navigators gave it the name of Kruse Zee—sea of dark weed. (Fucus natans of Linn; Sargassum natans, Lamouroux). The Sargazo Sea is now sometimes termed the "Gassy Sea" by English writers.
[43] A. Von Humboldt's MS.

3.—TABLE OF CURRENTS.

Name.	Origin and Direction of Course.	Extent.	Velocity.	Temperature.	Remarks.
THE GULF STREAM OR FLORIDA.	The Gulf Stream originates in the Gulf of Mexico, where the water, having become heated, is carried through the Strait of Florida. Issuing thence, the stream runs northward along the shores of Florida, to 31° north latitude, and then in a north-easterly direction, to Cape Hatteras. From the meeting of the winds, the western edge is now directed more towards the north, while the main stream continues towards the north-east, till it meets the St George and Nantucket Banks, when its course is directed to the eastward. Hence its direction is east-quarter-north, parting the southern extremity of the Bank of Newfoundland. It continues in this line to about longitude 38° west, between 35° and 43° north latitude. At this point, it turns towards the south-east and south, and, passing the westernmost of the Azores Islands, it is, in general, lost in the ocean. The warm waters are, however, sometimes extended to the shores of Europe, where they were observed by Franklin in 1786, and by Colonel Sabine, in the *ship* Lightning, in 1822. In both cases this extension was ascribed to the violence of the ocean temperature over that of corresponding seasons. Colonel Sabine found this in latitude 44° 30′, 3 degrees; and in latitude 39°, 6 degrees. "The greatest excess was found in or about latitude 39°, being the parallel where the middle of the stream, indicated by the warmest water, would arrive, by continuing to flow to the eastward of the Azores, in the prolongation of the great circle in which it is known to reach the wild Atlantic."[1] Following Major Rennel, Colonel Sabine attributes the occasional extension of the Gulf Stream, in particular years, to its greater initial velocity, occasioned by a more than ordinary influxion of the level of the Gulf of Mexico and the Atlantic. But if Rennel's opinion were correct, the Gulf of Mexico should have a much higher level than the Atlantic; it has been shown, however, that the depth of the current off Cape Hatteras is not half as much as at the Narrows of Bemini, shortly after it leaves Cape Florida;[2] hence, instead of descending, it actually ascends in its progress northwards; and this is also shown by the existence of a rapid counter-current of cold water, which passes southwards from the Arctic Ocean, between it and the American coast, to Cape Hatteras and Florida. Captain Manderson, R.N., ascribed the origin of the Gulf Stream to the Mississippi and other streams emptying themselves into the Gulf; but Captain Livingston shows this opinion to be erroneous, from the fact that the volume of water discharged through the Gulf Stream exceeds, by more than three thousand times, the amount discharged by the Mississippi.	The Gulf Stream extends, from its commencement to the west of the Azores Islands, upwards of 3,000 nautical miles, traversing in its course 20 degrees of latitude (from 23° to 43° north).	A table of the velocity of the Gulf Stream, in different parts of its course, will be found in the north-west corner of the Chart. From this it appears that the average rate from the Narrows at Bemini Island, to latitude 31° north, in sixty-three miles in twenty-four hours. In May 1804, Humboldt observed, in latitude 25° and 27°, a velocity of eighty miles in twenty-four hours, or five feet per second, although at the time the north wind blew with great violence. At the end of the Gulf of Florida, in the parallel of Cape Canaveral, its rapidity resembles that of a torrent, and is sometimes five miles an hour (120 miles per day). The velocity decreases gradually in its progress towards the east. Between 65° and 60° west longitude, it runs fifty-five miles per day; and at 42° 30′ west (900 miles farther east), from thirty to thirty-five miles per day; it diminishes more rapidly after it bends to the south, and in the vicinity of the Azores it is not more than ten miles per day. Major Rennel calculates that the stream arrives from its source in the Azores Islands (3,000 miles) in seventy-eight days, which gives an average rate of thirty-eight miles per day.	The maximum temperature of the Gulf Stream, in the Strait of Florida, is 86°, or about 9° above that of the ocean at the same latitude. At 30° farther north, it is 62° 5′, having lost little more than 2° in this space. At 63° west longitude, it is 61° in summer, and 56° 22 in winter. Five degrees farther east, it is 73°, at 56° west longitude, it is 77°. Five degrees more to the east, it is 75°; and at 40° west longitude, it is 73° 36. Thus the temperature, like the velocity, decreases as the stream progresses, but not so rapidly, having lost only about 15° in 3,000 miles; and even when it turns to the south, and spreads itself over the ocean, it still maintains the heat of summer. It cannot be doubted that this vast expanse of warm water, from 8° to 10° above the temperature of the sea, must have a great effect in mitigating the climate of the adjacent countries. "A simple calculation," says Lieutenant Maury, "will show that the quantity of heat discharged over the Atlantic, from the waters of the Gulf Stream, in a winter day, would be sufficient to raise the whole volume of atmosphere that rests upon France and the British Islands from the freezing point to summer heat." "It is the influence of this stream upon climate," he continues,[3] "that makes Erin the Emerald Isle of the sea, and clothes the shores of Albion with evergreen robes; while, in the same latitude on the other side, the shores of Labrador are fast bound in fetters of ice." In 1831, the harbour of St John's, Newfoundland, was closed with ice in the month of June, although it is 2° farther south than Liverpool,[4] and it will be seen from our Chart of Isothermal Lines,[5] that the influence of the Gulf Stream is felt in Norway and on the shores of Spitzbergen.	On leaving from the Strait of Florida, the water of the Gulf Stream is of a dark indigo-blue colour, and the line of separation between it and the green waters of the Atlantic is plainly visible for hundreds of miles.
THE MAIN EQUATORIAL CURRENT.	The Equatorial Current commences on the west coast of Africa, much further to the eastward than is generally imagined, and the Island of Annabon appears to be always environed by it. On crossing the Equator, its course is parallel with the Guinea Current for more than 1,000 miles; exhibiting the "remarkable phenomenon of parallel streams in contact with each other, flowing with great velocity in opposite directions, and having a difference of temperature of 10° or 12°. Thus, according as a vessel, intending to proceed along the coast in either direction, happens to be in the one or the other of these currents, her progress will be accelerated or retarded from forty to fifty miles per day."[6] Proceeding on both sides of the Equator to 22° west longitude, it sends off the *North West Brazil Current*, and then, declining gently to the south, it runs to within 300 miles of Cape St Roque, on the coast of Brazil, when it divides, the smaller and principal part, forming the *Guyana Current*, enters the Caribbean Sea. The southern division, flowing in the direction of the coast of Brazil, but at a considerable distance from it, forms the Brazil Current.	The length of this current is, from the coast of Africa to Cape St Roque, 2,500; or to its entrance into the Caribbean Sea, 4,000 nautical miles. Its breadth, near the commencement, is 100 miles; opposite Cape Palmas, 200; and before dividing, it is at least 430 nautical miles.	The greatest velocity occurs in summer, and the least in winter. From 5° west to 10° west longitude, the average is from twenty-five to thirty miles per day. From 10° to 16° west, towards the end of June and beginning of July, it varies from forty-four to seventy-eight miles;[7] between 15° and 22° west, it amounts to from forty-five to sixty miles. The most velocity ever observed, was eighty-six miles an hour, in thirty-four hours.	The average temperature is about 78°, or from 4° to 6° under that of the ocean at different seasons.	This current greatly impedes the progress of those vessels which cross the Equator to the west of 22° west longitude, impelling them beyond Cape St Roque, where they are driven towards the northern coast of Brazil, and cannot regain their course till after weeks or months of delay and exertion.
THE NORTH-WEST BRANCH OF THE EQUATORIAL CURRENT	Flows first in a north-west, and afterwards in a more northerly direction; it is always perceptible at 10°, and often at 30° north latitude, where it merges in the Drift Current, to which it appears to give a north-westerly direction and an accelerated course.	At the point of separation its breadth is above 200, and farther north it extends to 300, nautical miles.	Its velocity is much less than that of the Main Current; it is estimated at from twenty to twenty-four miles per day up to 18° north latitude, when it increases, and becomes gradually less perceptible.		This Branch Current is favourable to the progress of vessels in returning to Europe from the Southern Hemisphere.
THE GUYANA CURRENT.	This, which is a continuation of the Equatorial Current, runs along the low coast of Guyana to the Island of Trinidad. At the Equator it is crossed by the Amazon River, which, entering with great violence, forms eddies and whirlpools. This, however, seems to have no influence on its direction; for the waters of the river and the current do not mix, but, pouring the current, the waters of the river are observable at a distance of 300 miles from its mouth. At the Island of Trinidad, the Orinoco pours an immense mass of water into the current, which, entering at a very acute angle, soon mixes with, and considerably accelerates its course. The current enters the Caribbean Sea by the Strait between the Islands of Trinidad and Martinique. No perpetual current has yet been observed in the Caribbean Sea, although, as will be seen, it receives cold and discharges warm water at its two extremities.	This current extends about 500 miles.	Its velocity varies from ten to twenty-one and thirty-six miles per day at different times of the year. Colonel Sabine found it upwards of four miles an hour in the full strength of the current, while near the coast it gradually diminished to less than half-a-mile an hour.	The temperature of the ocean water, as observed by Colonel Sabine, was 81° 1, and of the river water 81° south, both within a short distance of the division.	The line of separation between the water of the Amazon and that of the ocean, runs north-west, 6° north, and the division was so distinctly preserved as if they had been different fluids.[8]
THE BRAZIL CURRENT.	This current flows at a distance of from 200 to 300 miles from the shores of South America, and extends from six to seven degrees into the ocean. The space between it and the coast is occupied by other currents which follow the direction of the movement. It is crossed by the River La Plata, which is observable at a distance of upwards of 200 miles in the sea, but appears to have little effect in changing the direction of the Brazil Current, which may still be traced, though much weakened, to the Strait of Magalhaens.		The average rate of this current, in its northern division, is about twenty miles per day.		Sir Woodbine Parish remarks, that 100 miles (Kotzebue says 200) before the voyager enters the Rio de la Plata, he may begin to see the turbid current, and had to struggle with its influence in the ocean itself.
CAPE HOORN CURRENT.	The Cape Horn Current flows constantly from the Antarctic and South Sea into the Atlantic Ocean, and is usually accompanied by westerly storms. Its general direction is east-north-east and north-east. Captain Fitzroy remarks, that he never saw the current run in any other direction; it had always an easterly course, from whatever point the wind blew; and this observation is confirmed by the journals of the Prussian navigators. On the eastern side of the continent it turns towards the north-east, and surrounds the Falkland Islands. In certain seasons it maintains its north-easterly course to the parallel of 42° or 43° north, when it turns to the north-east and east, and mixes, without doubt, although at an unknown distance, with the waters of the Southern Connecting Current.		Krusenstern remarked a velocity of from twelve to fifteen miles per day off Terra del Fuego. In longitude 74° 14′ west, latitude 57° south, the velocity was found to, on 23d December 1830, amount to thirty-five miles per day; and on 22d March 1833, in latitude 50° south, on the third voyage of the Princess Louisa, the observed velocity was at the rate of fifty-two miles per day. Between Cape Horn and Staaten Land, latitude 55° south, Captain Foster found it run towards the north 51° east, at the rate of fifty-six miles per day. According to Captain Fitzroy's observations, the velocity, in the vicinity of the coast, amounts to twenty-four miles per day.	This current, flowing northwards from the Antarctic Polar Sea, has a temperature much lower than that of the adjacent ocean as the atmosphere; but the amount of this decrease is not yet ascertained.	The results of the observations of Captain Ross, in the ship Chili-zion, on the voyage from Monte Video to Valparaiso (the source of which is inserted in the Chart), show that the maximum velocity, between latitude 36° 15′ and 36° 15′ south, longitude 49° and 72° 11′ west, amounts to four miles per hour (ninety-six miles per day), which is almost as great as that of the Gulf Stream. The general direction of the current on this course was east-north-east and north-east.
SOUTHERN CONNECTING CURRENT.	The part of the ocean occupied by this current is but imperfectly known, and it is doubtful whether it may be connected with the Brazil Current. It flows with an increased velocity to the eastward, passing 150 or 180 miles south from the Cape of Good Hope into the Indian Ocean, where traces of it are found at a distance of 2,900 miles beyond the Cape.				
THE CAPE OR AGULHAS CURRENT.	This current is formed from two streams issuing from the Indian Ocean, the principal of which is from the Channel of Mozambique, and the other from the sea south of Madagascar. When the collected stream has reached the meridian of Cape Recife, it is deflected southwards by the Bank of Aguilhas; and instead of passing entirely round or over the bank into the Atlantic Ocean, as was formerly believed, the greater part returns by the Counter Current back into the Indian Ocean, merging into the Southern Connecting Current, which, being by far the most powerful in this place, gradually causes it to return to the eastward, after the bank has recovered it from its westerly course.	Opposite Cape Recife, the current is from 90 to 100 miles broad.	In different parts of its course this current flows at the rate of from 60 to 100 miles per day.	Outside of the bank the temperature has been observed to be 70°, or 3½° above that of the ocean; near the edge of the bank 69°, or 6° above the ocean temperature; and on the bank the temperature has been found to vary from 5° or 6° above, down to ocean temperature itself.	Major Rennel says: "The line of direction of this current adds to the safety of the navigation when ships make their landfall at the head of Natal, as the Doddington Rocks and neighbouring islets are very dangerous." A winter passage round the Cape of Good Hope to the westward may depend on keeping in the stream of the Aguilhas Current. The Counter Current of the Cape was first noticed by Captain Horsburgh in 1798; later observations have shown that it has often a breadth of from 210 to 360 miles, and flows with a velocity of fifty miles per day.[9]
THE NORTH AFRICAN AND GUINEA CURRENT	Originates in the sea opposite the coast of France, between Cape Clear in Ireland and Cape Finisterre in Spain. It flows in a south and south-easterly direction to Cape de Vincent, between which and Cape Cantin in Morocco the whole mass of water, as far as 20° west longitude, sets into the Strait of Gibraltar. From Cape Cantin to Cape Bojador, it is directed more to the eastward, which is continued to Cape Blanco; but in the latter space it extends only from 150 to 180 miles from the land. At the Cape Verde Islands the current turns gradually towards the south, then, following the coast of Africa, it flows south-east and east-south-east, and, after passing Cape Monserado, its course is due east from the Bight of Biafra, flowing in contact with the Equatorial Current; and, after surveying Prince's Island, its waters are probably mixed with those of the Equatorial Current.	The breadth of this current varies with the season; opposite Cape Palmas, it has been found to extend to 120 miles.	Its greatest velocity is during the season of south-west winds (June to September). Near the beginning of its course it runs at the rate of twelve miles per day; after passing Cape Monserado, its rate is nearly fifty miles.	At the Cape de Verde Islands, the temperature is 8° lower than that of the surrounding ocean; but it increases rapidly to the southward; and in the Gulf of Guinea, in 1822, Major Sabine observed a temperature of 84° in mid-channel, diminishing from 82° to 80° in its southern verge, where it is in contact with the colder water of the Equatorial Current, and 79° and 81½° on its northern side, in the proximity of the land.	
RENNEL'S CURRENT.	This current, for a knowledge of which we are indebted to the indefatigable researches of the late Major Rennel, commences near Cape Finisterre, and running along the northern coast of Spain, turns to the north and north-west, along the west coast of France, and traverses the English and Irish Channels, touching the Scilly Isles on its eastern border; it then continues to Cape Clear, on the southern shore of Ireland, whence, entering the ocean, it turns to the south and south-east, rejoining the North African Current.		Its velocity amounts, in certain winds, to twenty-four and twenty-eight miles per day. Vessels are frequently endangered by it, near the Scilly Islands.		
THE ARCTIC CURRENT.	This current is understood to originate in the masses of ice which surround the North Pole, whence it runs along the eastern shores of Greenland to Cape Farewell; it doubles the Cape, and flows up the western coast of Greenland, to about 66° north latitude, when it turns to the south-west, along the coast of Labrador, forming the *Hudson Bay Current*. Arriving at the north end of Newfoundland, it sends a branch through the Straits of Belle Isle, which joins the outfall of the St Lawrence, while the main stream passes between the great and lesser Bank of Newfoundland, and meets the Gulf Stream between 42° and 42° west longitude. Here it divides, one portion (as is probable from the icebergs which are carried across the Gulf Stream) flowing southward to the Caribbean Sea, which it enters as an under current.[10] The other flowing south-west, past Nantucket Island, forms the United States' *Counter Current*, which extends between the Gulf Stream and the coast to Cape Hatteras and Florida. The Arctic Current thus replaces the warm water sent through the Gulf Stream, and mitigates the climate of the countries of central America and the Gulf of Mexico, which, "were it not for this beautiful and benign system of aqueous circulation, would have the hottest, if not the most pestilential, climate in the world."[11]				Captain Scoresby counted 200 icebergs setting out on the Arctic Current at one time. Such enormous masses of ice must bring with them immense quantities of stones and earth, which, being deposited at the edge of the Gulf Stream, probably led to the formation, or at least the extension, of the great Bank of Newfoundland. The dense fogs which, at Newfoundland, so often endanger navigation, may be accounted for by the meeting of the warm waters of the Gulf Stream with this cold current.

[1] Nautical Magazine, April 1845.
[2] Lieutenant Maury, in the American Journal of Science.
[3] American Journal of Science, xiv., p. 293.
[4] Meteorological Division of the Physical Atlas, Chart No. 1.
[5] Horsburgh's East India Directory, fifth edit. i.
[6] This is the greatest velocity ascertained by Bessel, but an instance of nearly ninety miles per day occurred in the centre of the current near the Island of St Pedro.—*Lieader und Vollerhaven.*
[7] Nautical Mag., May 1845.
[8] Schouten, its discoverer, in honour of his birth-place, the town of Hoorn on the Zuyder-Zee, in N. Holland. This town was also the birth-place of Tasman, the discoverer of *New Zealand* and Tasmania.
[9] The numerous observations which, for a series of years, have been made on board of the vessels of the Prussian Mercantile Marine, confirm, in a remarkable manner, the results stated by Major Rennel in his great work. Copious extracts from the journals of these vessels will be found in the author's Lieader und Vollerhaven, i.
[10] The temperature of the Caribbean Sea at a little depth is far below the mean temperature of the air, and as cold as that of the sea at a corresponding depth off the shores of Spitzbergen. At the depth of 240 fathoms, it has been found as low as 48°, while that of the surface was 85°.—*American Journal of Science, xxv, xxvii.*
[11] Ibid.

PHYSICAL CHART OF THE INDIAN OCEAN

Showing the TEMPERATURE of the Water,
THE CURRENTS OF THE AIR AND OCEAN, DIRECTIONS OF THE WIND,
DISTRICTS OF HURRICANES, REGIONS OF THE MONSOONS & TY-FOONS,
TRADE ROUTES &c. &c.

Extended from the Original Notes & Drawings of
PROFESSOR BERGHAUS, BERLIN,
BY A. K. JOHNSTON, F.R.G.S.

REFERENCE TO COLOURS

District of the S.W. & S.S.E. Monsoons	Green.
" S.E. & N.W. "	Yellow
Zone of the S.E. Trade or Passage Wind	Blue
District of the prevalent N.W. Winds	Orange
District visited by Hurricanes & Typhoons	Red
and the courses of remarkable storms	
Steam Packet tracks	Purple

EXPLANATION

The degrees of Temperature refer exclusively to the Warmth of the Ocean and are given according to Fahrenheit's scale, in upright figures thus (58.46) ——— The opening at this sign shews the direction of the Wind.

Hurricanes and Typhoons are represented thus ✦ ——— & the regions of the Monsoons this sign ⟶ shews the direction of the Ocean Current in the S.E. and this ⟵ in the S.W. Monsoon. ——— Tracks from Europe to India.

——— Track of the Steam Ship Berenice to Bombay in 1837. ——— Tracks from India to Europe. The small figures on the Tracks indicate the days of the Month, and the dot the position of the Ship at Noon each day. The figures placed beside the arrows pointing the direction & name of the Currents shew the Velocity of the Current in Geographical Miles in 24 hours.

Reference to the months, Jy. January, M. May, Mar. March &c. placed beside arrows shew the seasons at which the currents were observed.

NOTE

The indications of Temperature of the water in the Red Sea and between Socotra, Ceylon and Calcutta are from the observations of M.T. Philippi. (See text P.2)

NOTE

In the district of the Moluccas the S.W. Monsoon is the Rainy Season for all the West Coasts, while all the Eastern Coasts have the Dry Season. But when the N.E. Monsoon prevails, the East Coasts have the Rainy, and the West Coasts Drought.

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

Much of this weed is floated down by the Gulf Stream from the Mexican Sea; and it was formerly believed that it was torn from the Florida Reefs, and conveyed by the current to the middle of the ocean; hence its name of gulf weed. But from its immense quantity it is evident this cannot be the case; and later investigations render it probable that it propagates in the sea, and vegetates floating.[a]

Humboldt is of opinion that between the parallels of 20° and 45° north, there is an immense sand-bank on which this weed is produced. He observes, that "the greatest part of the sea-weed, south-west of the Azores, is fresh and full of vegetation, as if newly torn from the rocks; and soundings have been so seldom made in these weedy regions, that we may easily conjecture that the two groups of the Azores are not the only volcanic elevations in this quarter."[b] It is important to remark that Columbus was struck with the idea that the Fucus must have had its origin near the place where it was found. Every time he mentions it in his journal, he states whether it was fresh or decayed. This journal of its first discoverer is very important, as showing the remarkable permanence of the great Fucus Bank west of Corvo, which seems not to have changed its position since its appearance alarmed the companions of Columbus on the 16th September 1492.[c]

VI.—APPEARANCES OF VOLCANIC ERUPTIONS IN THE ATLANTIC.

In the Southern Atlantic there are evident signs of volcanic action. Within the space included between the Equator and latitude 3° south, and the meridian of 17° 40′ and 23° 40′ west, rocks and islands have been observed, which, in later times, seem to have disappeared, like those of Sabrina, at the west end of San Miguel (St Michael), Azores, in 1811, and Ferdinandea, or Graham's Island, on the south-west of Sicily, in 1831. The following are the facts regarding these appearances, stated in chronological order:—

Date.	Ship.	Observations.	Lat.	Long.
1747, October 17.	On board the ship Le Prince, Captain Beaubriant,	Two shocks were felt, as if the keel had grazed a sunken rock, in	1° 35′ S.	17° 50′ W
1754, February 5.	On board the French ship, Silhouette, Captain Pintault,	A shock was felt, like the effect of grounding on a bank, in	0 20	29 50
1758, April 15.	The frigate La Fidele, Captain Hoza,	Experienced similar shocks, in	0 20	18
1761, May 3.	Captain Bouvet, in the ship Le Vaillant,	Observed a sand island, in	0 23	19 10
1806, May 19.		Admiral Krusenstern "observed a rare phenomenon;" "A pillar of smoke sprung up, as high as the mast of a ship, which suddenly vanished, but again showed itself, and then entirely disappeared." Dr Horner was of opinion that this must have been the effect of a volcanic eruption—"perhaps the precursor of a new island."	2 32	29 44
1816, December 8.		Captain Proudfoot passed over a bank, which appeared to be three miles long from east to west, and one mile broad from south to north.	6 32	17 46
1831, April 12.	On board the ship Aquila, Captain Taylor,	A rolling shock was experienced under water, with a feeling as if the ship were rubbing upon a rock. There was no discolouration of the water, and the ship was not injured. Captain Taylor was of opinion that there had been a volcanic eruption, which lasted fifteen seconds.	0 22	21 6
1838, February 9.	The barque Crown, from Liverpool to Bombay,	Felt as if the keel passed over a coral reef. No soundings were got at 120 fathoms.	0 57	23 19
1842, March 16.	Captain Jessen, in the ship Gustav, of Hamburg,	Felt as if the keel passed over a shoal or sand bank. Effect of an earthquake!	7 0 N.	33 36

VII.—ICEBERGS AND DOUBTFUL ISLANDS.

In the Chart we have marked the limits of floating masses of ice in May and June in the Northern Hemisphere, and the positions in which some of these have been found in lower latitudes.[d] Ice-fields and bergs, the phenomena of which have been so lucidly described by Scoresby,[e] assume an infinite variety of shapes and appearances, their formation being ascribed to the breaking up of the immense glaciers which, during the winter months, occupy the valleys of the Arctic regions. Some of these ice-fields have been met with upwards of 100 miles in length, with an average breadth of fifty miles, and a mean elevation of from four to six feet above the water; while ice-islands have been calculated to attain the elevation of 180 or 200 feet.[f] "These immense masses of ice cool the surrounding seas, and give to the winds which blow from them a harsh and chilling influence."[g] The water is rendered sensibly colder to a distance of from forty to fifty miles around them, and in their vicinity the thermometer has been found to fall from 61° to 43° (Far.) In March and April, the spring months of the Northern Hemisphere, the Arctic or northern icebergs are usually observed in the North Atlantic Ocean to drift farther to the southward before they are dissolved than at any other time of the year.[h] They have been found in the Gulf Stream as far south as latitude 40° 55′ rapidly dissolving with the heat of the current. On the 18th and 19th April, the steam ship "Great Western" encountered a field of ice perhaps 100 miles in extent. The largest iceberg was three-quarters of a mile long, and the highest was 100 feet above the surface of the water. About 300 were seen by this vessel. The field-ice varied in thickness from two to four and a-half feet. The lowest temperature of the water was 25°, and of the air 28°. Some icebergs were met as low as latitude 42°. By different vessels the ice was encountered over an extent of seven degrees of latitude; that is, from 40° to 47° north. In May, extensive fields of ice were still encountered, often carrying plump seals in considerable numbers. Many vessels were injured, and several lost, by coming in contact with icebergs, or being encompassed by these floating fields—the probable fate of the steam ship "President."[i]

In the Southern Atlantic, icebergs being of comparatively rare occurrence, have been often mistaken for land, and notwithstanding their evanescent nature, they have in many instances maintained a position and a name in Charts of even recent date.

There are two doubtful islands, however, which seem to require more accurate research before we can determine as to their actual existence; these are—1. The Island of Columbus, which was seen from the sloop of the same name, Captain Long, on the 23d September 1809, and determined to be in latitude 30° 18′ south, longitude 28° 20′ west.[k] He described it pretty fully; and Flinders, although he did not himself see the island (as he was, at the nearest, eighty miles distant from it), remarked a great number of birds, amongst which were many land birds. He does not, therefore, doubt, any more than Long, that this is the island seen by the Dutch skipper Lindemann, from Monnickendam, on the 23d August 1670, and named by him Saxenburg Island, and which is usually laid down from his log-book in latitude 30° 45′ south, longitude 12° 30′ west. Partly very properly remarks, that the longitude mentioned by Long lies so near the course of Captain Cook in 1776, and other voyagers, that we have great room to doubt of its accuracy.[l] Horsburgh says expressly that the Island Saxenburg of the old maps does not exist;[m] on the contrary, Krusenstern, while he mentions the observations of Long, remarks, that it has been seen by another English ship, and thinks that more accurate observations of this island are still to be desired.[n] The Dutch captain, Pieterse, in the ship De Tromp, found himself, on the 11th July, 1817, near the position which is assigned to the Island Saxenburg, or Columbus, according to Captain Long, viz., in latitude 29° 57′ south, longitude 27° 18′ west, without mentioning, in his journal, his having met with any signs of land;[o] on the other hand, a great many such signs were observed on Foster's course from the Eastern Hemisphere to the Cape of Good Hope; so that Webster, the historian of Foster's expedition, remarks: "It appears that land still remains to be discovered in the South Atlantic Ocean."[p]

The other island is Isla Grande, which De la Roche thought he discovered on his voyage from the South Sea to Europe in 1675, but which was sought for in vain by Cook, La Pérouse, Colnett, and Vancouver. This island has been placed in latitude 45° south, sometimes in longitude 35° 50′ west, sometimes in 38° 30′, sometimes in 40° 30′ west; and Captain Haig believed that he had re-discovered it in March 1834, in latitude 46° 40′ south, longitude 48° 25′ west; that this, however, was not the case, and that he had only seen a floating island of ice, to which he attributes the enormous height of 1000 feet above the level of the sea, has already been pointed out,[q] and completely confirmed by the Prussian captain, Rieck, in the merchant ship Christian, who, on the 10th September 1827, sailed exactly over the place which Haig assigns to his Isla Grande, without having found any trace of it. Land was really seen from the ship Sabaria, in latitude 44° 45′ south, longitude 43° 20′ west,[r] a position which again falls in the neighbourhood of Captain Reick's course, without his making mention of any land whatever. The Prussian voyagers agree with all others who have sought for Isla Grande (among whom Livingston, 1824–25, and Lincoln, must be named), that in this district of the Atlantic Ocean there are many signs of land, and, therefore, we have not hesitated to retain the Isla Grande provisionally, according to two readings of longitude. Upwards of ten years ago, it was distinctly ascertained that the Aurora Islands, the position of which was determined with extraordinary precision, on the expedition of the Descubierta and Atrevida, were nothing more than floating icebergs. One may well be surprised, therefore, to find them still inserted in the latest Charts. The designation which we have given them, in spite of the name "Aurora Isles," leaves no room for doubt as to their true importance. The determination of the existence of islands and dangers in the Southern Atlantic is of the more importance, as hitherto it appears that too little caution has been used in avoiding icebergs, which have been found even in the neighbourhood of the Cape of Good Hope; and it is to be feared that many ships have been lost by striking against them during the night, in tempestuous weather; of which, H.M.S. Guardian affords a sad example. This vessel, bound for Australia with stores, "struck against an ice-island in a foggy night, in latitude 44° 30′ south, longitude 44° 30′ east; she soon after nearly filled with water, and the chief part of the crew left her in the boats; but Captain Rion and a few of the people remained in the ship, and suffered great hardships. She continued nearly full of water, and was tossed about a considerable time without a rudder, until she was discovered by a Dutch packet, and towed into False Bay, at the Cape of Good Hope, five weeks after this misfortune, where she was wrecked, by driving on the shore, with several other ships, in a storm."[s] Captain Weddell gives a graphic account of the dangers to which vessels are exposed, and the narrow escapes they often make from ice-islands. The following incident occurred in the month of November 1823:—"On the morning of the 12th," he says, "we had closed with a large ice-island, and, in spite of all our endeavours to avoid it, we continued approaching. At ten o'clock it was within two ships' length, and, from its peculiar shape, threatened to overwhelm us: for the upper part of the side nearest to us, which was about 180 feet high, projected so much as would have admitted the brig's masts coming in contact with it underneath; and this overhanging part was cracked from the top down to the water line. Within half-an-hour, I had the appalling sight of the overhanging mass immediately over our quarter-deck, with the fearful sensation, that if our masts came in contact with it, the projecting part would fall upon us, and sink both vessels. Our escape was caused solely by our having a large flat piece of ice between us and the ice-island, which prevented our masts from touching it."[t]

The following circumstances, the particulars of which we extract from the *Nautical Magazine*,[u] may help to account in another way for some of the doubtful shoals and dangers given in Charts of the Atlantic Ocean, with various and uncertain bearings. On the passage from Rio de Janeiro to the Rio de la Plata, "I observed," says the writer, "a shoal of whales sporting nearly a-head, and went forward and seated myself on the cathead, in order to observe them better. I had scarcely done so when we were in the middle of them; and a huge monster, with its back out of the water, coming a little oblique to our course, received the whole momentum of the vessel on his forehead. This must have been stunning, as we were going at the rate of about nine knots an hour, and the vessel felt as if she had struck on a mud-bank." Vessels of a less firm texture may have met with similar encounters without surviving to tell the tale, or, especially if they occurred in the dark, may have been disabled without ascertaining from what formidable antagonist they received the blow.

[a] Barrow's Voyage; Burghaus, Länder und Völkerkunde.
[b] Länder und Völkerkunde, i., 416.
[c] Navarrete Primer Viage de Colon, i., p. 5.
[d] See further in the Chart of Isothermal Lines—Meteorological Division, No. 1.
[e] Account of the Arctic Regions.
[f] Since floating ice shows only one-eighth of its bulk above the surface, this indicates a thickness of 1600 feet but as icebergs are frequently found aground, this cannot be assumed as a general rule in judging of their magnitude.
[g] Forry, Climate of the United States.
[h] Horsburgh.
[i] Forry, Climate of the United States, p. 86.
[k] Flinders' Voyage to Terra Australis, i., pp. 54, 55.
[l] Purdy, Oriental Navigator; Table of Positions, p. 16.
[m] Beiträge zur Hydrographie der Grönsees Oceans, p. 26.
[n] Almanak ten Dienste der Zeelieden voor het Jaar, 1824, p. 202.
[o] Narrative of a Voyage to the Southern Atlantic Ocean in 1828–30.
[p] Nautical Magazine, January, 1835, p. 6.
[q] Horsburgh.
[r] Ibid., p. X.
[s] Voyage towards the South Pole.
[t] East India Directory, i., p. 73.
[u] August, 1844.

PHYSICAL CHART
OF
THE INDIAN OCEAN.

I.—INTRODUCTORY NOTE.

In the construction of this chart, we have found it necessary to alter the plan adopted in the other hydrographical charts of the PHYSICAL ATLAS, by combining in one sheet the meteorological with the hydrographical conditions of this part of the ocean. The peculiar structure of the land surrounding this vast basin prevents that regularity of motion in the currents of the air and water which is apparent in the Atlantic and Pacific Oceans, and renders a constant reference to one kind of currents necessary in explaining the others. Besides, the great importance of a knowledge of these aërial currents to the navigation of this much-frequented sea required that their limits should be delineated on a larger scale than was admissible in the general meteorological map of the currents of air; and although, on this account, this chart is more complicated than the others, we have succeeded, by the use of signs and colours, in rendering it equally distinct. The Indian Ocean, bounded on the north by the countries of Asia, is divided from the Pacific, on the east, by the Indian Archipelago and Australia; and from the Atlantic, on the west, by Africa; while its southern limit is generally understood to be formed by a line drawn from the Cape of Good Hope to Bass Strait. Beyond these limits on the south-east, the chart includes the regions of the China Sea, and part of the Pacific Ocean, showing the extension of the monsoons and typhoons. In the chart of the Pacific Ocean, we have traced the great Equatorial Stream from its origin in the Antarctic Drift Current, northwards, along the shores of South America, and westwards, through the Great Ocean, where it occupies the entire space between the tropics, to the Philippine Islands, where its westerly progress is interrupted by the shores of China, the south-eastern peninsula, and the numerous groups of islands which obstruct its passage. But the main stream is again recognised in what may be termed the Equatorial Current of the Indian Ocean, which continues to flow in a westerly direction, between the parallels of 10° and 25° south, till, in about the meridian of the Island of Rodriguez, it turns to the north-west, and passing the northern end of Madagascar, it enters the Mozambique Channel, where, flowing along the eastern coast of Africa, it forms the Cape Current, which, as we have already seen,[1] enters the Atlantic Ocean, and joining the northern branch of the Main Equatorial Current, forms the origin of the Gulf Stream; while the southern waters of the Atlantic, flowing round the southern extremity of South America, enter the Pacific Ocean, in order to commence anew the circuit of the globe. Such is the general course of these remarkable currents, flowing uniformly, when uninterrupted, from east to west, in a direction contrary to that of the diurnal motion of the globe, yet so deflected by numerous obstructions as frequently to run in an opposite direction, causing the various whirls and counter-currents so perplexing to navigators. The effects which these currents produce on the climate of the coasts and islands in their vicinity may be estimated by comparing the difference of temperature in the ocean, at different parts of its *surface*,[2] thus, in the middle of the tropical regions, at certain seasons of the year, the water of the Equatorial Current, in the Pacific Ocean, is under 69°, while the still water beyond its limits is upwards of 80°. The waters of the Gulf Stream, on the contrary, in different places, are from 3° to 10° higher than those of the surrounding ocean.

II.—NAVIGATION OF THE INDIAN OCEAN.

Scientific seamanship has nowhere achieved more valuable triumphs than in the navigation of the Indian seas. The progress of the present season of the year may be observed, and thereby to expect the existence of the prevailing winds at the different seasons, but how to turn them to the best advantage in prosecuting his voyage. "It is one of the chief points of a seaman's duty," says Captain Basil Hall,[3] "to know where to find a fair wind, and where to fall in with a favourable current. If," he says, "we take a globe, and trace on it the shortest route by sea to India, and then fancy that such must be the best course to follow, we shall be very much mistaken. And yet this is very much what our ancestors actually did, till time, and repeated trials, and multitudinous failures, gradually taught them where to seek for winds; and how to profit by them when found. According to this rule of thumb sailing, a ship had only to steer from England to Madeira, pass the Canaries and Cape de Verds, and then to make a direct course to the Cape, and thence to India. On trial, however, this experiment always failed; for, on getting near the equator, a series of calms and squalls put a stop to this meridional avenue, and the mariners of old were then forced to the coast of Africa, or rather towards that of the Brazils, and very often they came back in utter helplessness." Having already[4] adverted to the routes usually followed in sailing from Europe to the Cape of Good Hope, we shall now point out the tracks thence to the coasts of India, China, &c. as laid down in the charts.

From the Cape of Good Hope the voyager has the choice of several routes to the different parts of India, in the selection of one or other of which he must be guided by the season of the year, and the consequent direction of the monsoon winds. The most frequented of these are thus described by Krusenstern:—1. The Inner or Mozambique Passage; 2. The Passage to the eastward of Madagascar; 3. Bouguen's Passage; 4. The Middle Passage; and, 5. The Outer Passages.

1. *The Inner Passage*, which is the most direct, is through the Mozambique Channel, between Madagascar and the coast of Africa. This route is followed when the voyager leaves the Cape of Good Hope at such a period of the year as may lead him to calculate on arriving at the coast of India during the prevalence of the south-west monsoon. This passage is safest during the dry season, or from April to September, at which time the winds generally blow from south-south-east to the south-west; and as the latitude is increased, they will be found to veer to the south-west. Following this course, Krusenstern left the Cape on 27th June, 1797, crossed the line on 20th July, in longitude 46° 30′ east, passed the Island of Ceylon on the 2d, and anchored in Madras Roads on the 4th August, having performed the voyage in 40 days.

2. *Passage to the eastward of Madagascar.* On this route the course is first easterly, and only so far to the north as is necessary, in order not to arrive within the region of the south-east trade-wind before reaching longitude 53° east, if this wind were met with sooner, it might be difficult to proceed to the eastward, especially in the parallel of the south-east part of Madagascar, where the *Fort Dauphin winds* usually blow strong from the east-north-east. The track is now northerly till the voyager quits the south-east trade wind and enters the region of the south-west monsoon, by the assistance of which he may easily reach any part of India.

This passage is also chosen when the navigator expects to reach India during the south-west monsoon. Many voyagers, alarmed by the dangers in the Channel of Mozambique, choose this route instead of the inner one; and although the distance is greater, some ships make the passage in a shorter time; but Krusenstern thinks that, since these dangers have been carefully observed, the inner passage is to be preferred. Horsburgh[5] is of opinion, that in the months of August and September the passage east of Madagascar should be preferred, and that from February to May the inner passage is to be chosen with advantage. He sailed from the English Channel on the 20th April, 1802, and following this course, anchored in the Roads of Bombay on the 39th July; thus completing the voyage from England to India in three months.

3. *Bouguen's Passage*, so named from Admiral Bouguen, who, in 1748, took this route with a fleet of 26 sail, and made a very quick passage to India. This track is to the north-ward of Mauritius, to the east of Galega Island, and west of Machin Bank. (See the Chart.) Bouguen directly by ships bound for Bombay or the Malabar coast, which are in late in the season that they cannot expect to arrive there before the setting in of the north-west monsoon. For ships which do not pass the Cape before the 1st September, this and the middle passage are the most advantageous, because, keeping far to the eastward, they will be nearer the coast to which they are destined at the approaching north-east monsoon.[6]

4. *The Middle Passage* is to the eastward of the former, having the Madagascar Archipelago to the west, and the Chagos Islands to the east. To enter this passage from the Cape of Good Hope, the course is due east till about longitude 67° or 68° east, when, crossing the parallels of 28° or 27°, and arriving within the region of the south-east trade wind, a true north course is proper, keeping in about longitude 68° east, as long as the south-east trade wind will serve. In the vicinity of the equator westerly winds are not infrequent; by the help of these, ships proceed to the north-west, or even through the equator, indeed, the favourable wind of the north-east monsoon sets in; but at the beginning of this monsoon the winds are oftener north-west than north-east, and, if not too strong, they are the more favourable for ships reaching the coast of Malabar, since the north-east monsoon arrives here 15 or 20 days later than on the southern coast of India.

5. *The Outer Passages*, or those to the eastward of the Chagos Isles. The most easterly of these is selected when ships are expected to arrive at Madras or in the Bay of Bengal during the full force of the north-east monsoon. The following directions, it is necessary to keep well to the eastward, in order that this wind may favour them in reaching the place of destination. The usual route is as follows: From the Cape of Good Hope the course is so far to the eastward that the south-east trade wind is sought to be met with first in longitude 80° or 85° east; it is then necessary to steer nearly due north, by which the longitude is a little amplified—that is, till the ship nears Cape Aitchin (or Achem), the northern point of Sumatra, without, however, coming in sight of it, because in its vicinity light north-west and westerly winds usually prevail; and besides, a strong current sets with force to the eastward.

From the meridian of the north end of Sumatra, the navigator bound for Bengal shapes his course westward of the Nicobar and Andaman Islands to the Ganges.[7] If the destination of the ship be to the coast of Coromandel, it is not necessary to approach so near to Cape Achem; it is sufficient to make the longitude of 90° east, whence, with a favourable wind, the course may be direct for Madras or Ceylon. From these examples, the difficulty of sailing from one part of India to another, during the prevailing monsoon, may be understood. A voyage from Calcutta to Madras, or from Madras to Bombay, may be made in a short time during the south-east, but not so during the south-west monsoon.

For example, a ship which sails from Madras to Bombay, during the prevalence of the latter wind, must increase the longitude at least 5°, and cross the equator far to the eastward; the south-east trade wind, which is often met with for the first time in latitude 10° or 12° south, must now be sought for, and with the assistance of this the navigator has to the westward 20 or 25°, or until he reaches the meridian of 8° or 10° west of Bombay, when he crosses the equator for the second time, and comes again into the region of the south-west monsoon, which is now a favourable wind for sailing to the latter port. See on the chart the northern course from Bengal and Madras to Bombay in the south-west monsoon; and also the northern route, which can be followed only in the month of July. The voyage from Bombay to Madras, during the *contrary* or north-east monsoon, is beset with nearly as great difficulties as the former. The course from the Cape to Madras or Bengal during the south-west monsoon, as shown in the chart, enters the zone of the south-east trade wind in about the meridian of 80° east, whence the course is nearly due north to the point of destination. A comparison of these circuitous routes taken by sailing vessels with the tracks of steamers along the coast, shows the great importance of steam navigation in the Indian Ocean.

ROUTES FROM THE CAPE OF GOOD HOPE TO CHINA, &c.

See on the chart the great route from Europe to China, during the south-west monsoon, on which we have given the track of the Netherlands ship, *De Tromp*, from the Atlantic Ocean to Sunda Strait, with the position of the ship every day at noon. The best course for ships which have no occasion to touch at the Cape of Good Hope, is to pass it in about latitude 37° or 38° south, in order to avoid the strong westerly current of the Cape, and to take advantage of the easterly counter-current. From the meridian of the Cape to that of the Islands Amsterdam[8] and St. Paul, the easterly course is usually run between the parallels of 36° and 40° south; latterly, the parallel of 37° has been preferred. because it is believed that there the winds are more steady than in higher latitudes: To insure the direct passage to China, a ship should be on the meridian of these islands not later than the 1st of July, so as to arrive in August.[9] From the meridian of Amsterdam Island the preferable course is to cross the meridian of 80° in about 38° south, and the meridian of 90° in about 32° south, in order that on arriving at latitude 29° the ship may be nearly on the meridian of the north-west point of Java, whence the route is by the westward of Christmas Island to Java Head. Through Sunda Strait, the passage is either by Croesatou Channel or Princes Strait. From the Strait of Sunda the course is nearly due north through the Strait of Banca or Gaspar into the China Sea, crossing the equator in the meridian of about 105° 30′ or 105° 40′ east.

From May till October the south-east, and from October till May the north-east, monsoon prevails in the China Sea. In the waters adjoining this sea the same winds occur north of the equator; but southward of the line, to about latitude 10° south, the direction of the wind is ten or twelve rhumbs, or points of the compass, different; that is to say, if on the north side of the equator, the north-east monsoon prevail; on the south it is west-north-west and west; and if the monsoon in the north is south-west, in the south it is east-south-east and east; hence, south of the equator these are called east and west monsoons. The currents in general follow the same direction as the winds, and since, as Krusenstern observes, "it is scarcely possible to overcome both, the navigator is obliged to seek, outside the China Sea, such winds and currents as will enable him, by a direct course, to reach the desired haven." The importance of an exact knowledge of the winds and currents of the Chinese and neighbouring seas may be conceived, says the learned admiral, when we reflect that, according to the course of the favourable monsoon, each month renders the adoption of a different route necessary. "I know several cases," he says, "in which ships were detained in these seas for a whole year, simply from a want of this knowledge; among others, I saw a ship which had been allowed to remain in Batavia too late in the season, make two ineffectual attempts to reach China by an easterly course; the natural consequence was, that she was obliged to wait the return of the south-west monsoon, by which she lost an entire year." From Banca or Singapore Strait, the inner passage (west of the Pareels) is generally the most expeditious route in March, April, and May; but in June, when the south-west monsoon sets regularly in, the track by the Macclesfield Bank is preferable. Ships which arrive at Polo Sepata later than September, find it very difficult to make a direct course to Canton, on account of the strong southerly currents and northerly winds which then prevail; experience has taught that, in these circumstances, the best course is to stretch to the eastward, where, along the coast of Luzon, changeable winds, often from the south-east, are met with in the month of October.

Eastern route to China during the north-east monsoon. (See the Chart.) This is the best course for ships bound for China direct, which leave the meridian of Amsterdam Island from the middle of September to December. The usual routes are, as shown on the chart, along the west coast of Australia, through some of the straits east of Java, and into the Pacific Ocean by Macassar Strait, the Molucca Passage, Gilolo Passage, or Dampier Strait, thence to the west of the Pelew Islands, and into the China Sea by the Strait of Formosa. Horsburgh gives the preference to the latter of these tracks, namely, that which passes to the west of Bouro, and enters the Pacific by Dampier Strait, thence to the west of the Pelew Islands, and into the China Sea by the Strait of Formosa. In the latter part of January or February, the best course from Amsterdam Island is not to enter the Pacific, but, passing through Macassar Strait, to steer along the west side of Mindanao and Luzon.

The Great Eastern Passage from Europe to China during the north-east monsoon. This route which, as shown on the chart, is due east from the Cape of Good Hope to Australia, is the safest and most speedy for ships which leave the Cape late in the season. This track was followed by Captain Butler in the ship *Walpole*. He left the Cape at the end of September; on 31st October, he saw the south-west point of Van Diemen's Land; on the 18th November, the Island of Amsbolon, one of the New Hebrides; on the 20th, the north-west point of Bougainville, which he discovered a "new mountain range," on the 21st, he passed the Marianna Isles; on the 30th, he entered the Strait of Formosa, and on the 1st January anchored in the Roads of Macao; thus performing the voyage in three months—a period little surpassed by the steamers of the present day. The voyage of the *Athenian*, which was two months is reckoned a *fair* average from the Cape to Sunda Strait, and three weeks to the Canton River; the whole voyage from the English Channel to Canton being reckoned at from five to six months. Instead of passing to the south of Tasmania, ships often steer through Bass' Strait. This route was followed by the frigate *Athenian*, with a convoy of ten sail, in 1844. They passed St. Paul's on the 10th October, entered Bass Strait on the 23th, and, passing to the east of the New Hebrides, came in sight of the coast of China on the 28th December. Notwithstanding this example, and the safety of this route, Horsburgh gives the preference given the preference given to the Inner Channel and Torres Strait.

In higher latitudes westerly winds are more to be depended on, and the northerly winds and southerly currents, so frequently met with at the entrance to Bass Strait, are thus avoided.

Return Routes from China and India to Europe. The object of the navigator is to get, as quickly as possible, into the region of the south-east trade wind, by the aid of which the voyage to the westward is speedily accomplished. In latitude 14° or 15° south, this wind is generally fresh and steady, and it increases in strength towards the south-west. This is especially the case in the parallels of 18° or 20° south, where it blows powerfully than in the latitudes of 14° or 15°; but in the months of March and April it is liable to interruptions, and sometimes entirely fails in the vicinity of the tropics.

In returning to the Cape of Good Hope from Bengal or the Strait of Malacca, ships must cross the equator in about latitude 89° east, and shape their course to the eastward of Rodriguez. From Madras, Ceylon, and the Malabar coast, the course is by the eastern or outer passage, cutting the equator to the eastward of 83° or 84° east, and steering towards Rodriguez and the neighbouring islands. During the north-east monsoon, the best course from the west coast of India, the Persian Gulf, and the Red Sea, to the Cape of Good Hope, is by the inner passage through the Channel of Mozambique, but this cannot be followed with advantage either very early or very late in the season, for then southerly winds are met with, which frequently cause delay and danger. Numerous examples of the return route from China are given on the chart, chiefly from recent voyages of the ships of the Royal Prussian Marine. It will be observed, that the "high-way" from the Eastern Seas to Europe lies through the centre of the hurricane district, and hence these storms are, in general, only met with on the return voyage.

STEAM NAVIGATION IN THE INDIAN OCEAN.

The tracks of the steam packets from Suez to Bombay, and from Aden to Ceylon, Madras, Calcutta, and Hong Kong, by the so-called "Overland Route," are coloured *purple* on the chart; and the following table shows the

COMPUTED DISTANCE BETWEEN THE PRINCIPAL PORTS, AND THE AVERAGE TIME OCCUPIED IN THE VOYAGE.

MAIL PACKET ROUTE TO BOMBAY.	Nautical Miles.	Average Days.
London to Marseilles *via* Calais and Paris[a] (regular course of post),	846	5
Marseilles to Malta (by her majesty's post-office packets),	660	4
Malta to Alexandria,	856	4
Alexandria to Suez (including all stoppages),	216	2
Suez to Aden (two days' detention included),	1359	8
Aden to Bombay,[b]	1630	10
London to Bombay,	5857[c]	34
The distance from Southampton to Bombay is	6254	
And the average time is from two to eight days longer than by the mail route.		
The longest interval between London and Bombay, by the mail packet, for the year 1843–44, occurred with that which left London on 15th November, and arrived at Bombay on 23d December 1843, *via* Marseilles, 38 days.		34½
The shortest for the same period, was that of 6th May, which arrived on 6th June 1844,		31 days.
The longest interval from Bombay to London, during the year 1844–45, was by the packet which left Bombay on 8th February, and arrived at London, *via* Marseilles, 24th March 1845,		44 days. 35½
And the shortest, for the same period, left Bombay on 2d December, and arrived at London, *via* Marseilles, 3d January 1844,		33 days.

[a] Captain Lyon, Edin. Coll. Lib., Chins, vol. ii. p. 305.

[b] Arrangements are at present (September, 1845) being made, under the direction of Lieutenant Waghorn, for conveying the India mails through Germany by Trieste, which being 500 miles shorter than the route by Marseilles, and having the advantage of several hundred miles of railway, will, it is expected, effect a great saving of time in the transit to Egypt.

[c] Formerly it was usual for steamers, after leaving Bombay, to steer as, that by making a long detour to the south-west, they would succeed in passing between Socotra and the African shore, near Cape Guardafui, which was become so accustomed to the line of the Monsoon. A northern route, near the coast of Arabia, has been recently tried, during the monsoon, and proved highly successful. The adverse currents along the African shores have been ascribed at from two to three knots per hour; along the Arabian coast they are scarcely felt.—*Nautical Magazine*, 1845, p. 42.

[1] Notes to Map No. 1, Hydrog. division.

[2] The temperature is referred to Fahrenheit on all the charts by Roman figures, enclosed within parentheses, in degrees and parts of Fahrenheit's scale.

[3] Patchwork, vol. iii., p. 270.

[4] See Chart of Atlantic Ocean, and Notes.

[5] East India Directory, vol. i., p. 159, 5th edit. 1841, to which the reader is referred for the most complete and accurate instructions for navigating the eastern seas.

[6] Horsburgh, vol. ii., p. 105.

[7] It was formerly thought that the passage to the eastward of these islands was the only secure route to Bengal during the north-east monsoon; but it is now well known that light north-west winds and southerly currents prevail along the Aracan coast at this season, which makes the passage along it to the northward very tedious.—*East India Directory*, i., 134.

[8] Amsterdam Island is laid down in the chart in latitude 38° 52′ south, longitude 77° 37′ east, from the surveys of the *Beagle*, Captain Stokes, who observes, "It is singular, that though this island, which is almost a degree-post for ships bound from the Cape either to New Holland or India, has been so long known to all navigators of those seas, its true longitude should have been till now unascertained." In recent charts and tables it is placed in latitude 37° 52′, or 64 miles further north.

[9] Or about 6100 statute miles.

SOUTHAMPTON TO MADRAS AND CALCUTTA.	Nautical Miles.	Average Days.
Southampton to Aden,	1604	24
Aden to P. de Galle (Ceylon), two days' detention included	2130	11½
P. de Galle to Madras,	540	3
Madras to Calcutta,	730	4
Southampton to Calcutta,	8024	42½
The longest voyage by the mail packet, for 1843–44, was to Madras, 45 days,		
The shortest, for the same period, was 36 "	}	
The longest to Calcutta, during the same season, was 47 "	}	42½
And the shortest 38 "		

SOUTHAMPTON TO HONG KONG.		
Southampton to P. de Galle (Ceylon),	6754	35½
P. de Galle to Pulo Penang',	1209	7
Pulo Penang to Singapore,	380	2½
Singapore to Victoria, Hong Kong,	1440	10
Southampton to Hong Kong,	9774	55

The average interval of transmission of the China correspondence, *via* Calcutta and Bombay, by the 20 overland mails, from 10th October 1841 to 9th May 1843, was 69 days, which exceeds the period occasionally occupied by fast-sailing ships in accomplishing the voyage *via* the Cape of Good Hope.[1] By the direct route *via* Ceylon and Pulo Penang, the voyage is accomplished, as above, in from 50 to 60 days.[2]

CALCUTTA TO SINGAPORE.		
Calcutta to Malacca,	1290	
Malacca to Singapore,	150	
Calcutta to Singapore,	1440	15
Singapore to Batavia,	480	8

STEAM PACKET ROUTE BY THE CAPE OF GOOD HOPE.

The first attempt to establish a steam communication with India by the Cape was made in the *Enterprise*, which left Falmouth on the 16th August 1825, reached the Cape of Good Hope on the 13th October, in 56 days, and arrived at Calcutta on the 9th December, having occupied 145 days on the voyage. This important experiment, although at the time considered a failure, reflects the greatest credit on its originators, and affords a most favourable prognostication of the ultimate triumphs of steam navigation in the open ocean.

Valuable as the route by the Red Sea undoubtedly is, that by the Cape offers many advantages peculiar to itself, among which may be specified the freedom from interruption by pestilence or political changes, and the direct benefit that will thereby be conferred on the colonies on the west coast of Africa, the Cape, and the Mauritius. And it appears that by this route passengers and letters may reach the presidencies of Calcutta and Madras nearly as soon as by the other, letters by the *Hindostan*, direct from England (*without stoppages*), having arrived at the former place in 39, and at the latter in 45 days.

The distance from Falmouth to Calcutta by the Cape is calculated at 11,250 miles, and it is expected that the voyage (*including stoppages*) will be performed in from 60 to 65 days. The average passage of the fastest sailing ships between England and Calcutta is, according to Mr. Little's analysis, between 95 and 100 days.[1]

CURRENTS OF THE INDIAN OCEAN.

In the southern part of this sea the Equatorial Current, which, as observed in the introductory note, connects the currents of the Pacific with those of the Atlantic Ocean, flows from east to west at a rate varying with the different seasons. To the northward of the Island of Madagascar, where its extent is greatly circumscribed previous to its junction with the Mozambique Current, its rate of progress may be averaged at from 42 to 60 miles in 24 hours.

Mozambique Current.—A south-westerly current is observed to flow along the African coast towards the Channel of Mozambique, during the whole year, which may be thus explained: The trade wind, which prevails in the South Indian Ocean, driven the water through the numerous groups of islands north-east of Madagascar towards the coast of Africa, whence it is repulsed and turned into the Channel of Mozambique, forming a constant southerly current, which is strongest during the prevalence of the south-east monsoon, and proportionally weak during the opposite or north-east monsoon. It is most rapid in the vicinity of the coast, where, as its name implies, the current is always powerful and proverbially powerful. Its mean velocity varies from 18 to 28 miles in 24 hours; but this rate is greatly exceeded in particular circumstances; and Horsburgh quotes the extraordinary case of the ship *Northampton*, which made 300 miles in 24 hours, or 54 miles per hour,[2] a velocity which finds a parallel only in the maximum of the Gulf Stream. At Cape Padron the Mozambique Current passes into the Cape Current, on its junction with the westerly current from the south of the Island of Madagascar, as noticed in the notes on the currents of the Atlantic Ocean. To the eastward of the Mozambique Current, on the Madagascar side of the channel, there is generally a counter current flowing northwards.

On the northern side of the equator, the periodical winds, the land and sea breezes, and the general changes of the seasons, exert a powerful influence on the surface of the sea; but those which affect the waters of which they are produced, or the forms of the coasts along which they flow.

In the *Bay of Bengal* the currents are entirely dependent on the monsoons. During the south-west monsoon, a northerly current (as shown by the arrows on the chart) flows along the Coromandel coast, beginning early in February, and increasing in strength till April and May, when the wind blows with the greatest constancy from the south. After this season it decreases in strength, but does not cease to flow till the middle of October, when it becomes very weak, and occasionally takes a southerly direction. In the middle of the north-east monsoon, during March and April, is variable, and seldom strong. Between the coast of Coromandel and the Nicobar Islands, and between the latter and the entrance to the Malacca Strait, it often flows to the south-west, whilst in the northern part of the bay it has a southerly course in March, and in April its direction is frequently northerly. In the month of April the general north or north-east movement commences over the whole surface of the bay, and continues till the beginning or middle of October. During this period the velocity of the current depends on the strength of the monsoon wind; and its direction is very inconstant, since on the east side of the bay it sometimes flows south through the Strait of Sunda, and sometimes out through the north-east channels the system of counter currents begins. On the Coromandel coast the southerly current is observed towards the middle of October, at the end of which, or early in November, it is very strong, raining, in the vicinity of the land, often at the rate of two miles an hour. At a distance of two or three degrees from the coast, and in the middle of the bay, the south-west current begins to be felt in the middle of October or November, when the north-east monsoon has attained a certain force; before this occurs it is variable, being sometimes south-south-west, and even north-west. In January the current decreases in strength on the coast of Coromandel and Orissa, and in February is almost entirely disappears in the vicinity of the land, as well as in the middle of the bay.

Nicobar Islands.—Between the Nicobar and Junk Ceylon Isles the current sets strong to the north-west and north during the north-east monsoon. On the coast of Arracan the prevailing direction of the current is to the south, although an opposite direction is sometimes observed.

Palks Strait.—During the north-east monsoon, the current frequently flows to the south-west and west, in Palks Strait, between the continent of India and the Island of Ceylon. In October and November a strong current sets along the east coast of Ceylon, following the south coast west-ward to Point de Galle, and even to Columbo. Above Great Basses it runs with a velocity of one and a-half to two miles per hour, and when the monsoon blows strong it is increased to two and a-half and three miles, but at other times it is comparatively weak. During the south-west monsoon these currents flow in an opposite direction, but their velocity is not nearly so great as in the former case, at least near the coast.

Maldive Islands.—At the long chain of the Maldives the currents generally flow in an easterly direction, but local causes produce great deviations. When in June, July, and August, the south-west monsoon blows with full force in the district of the Northern Atolls, the current runs eastward with the wind; while late in June, July, and the early part of August, when the south-east trade wind approaches the equator in the southern part of the chain, the current often runs west-north-west. On the east side of the Northern Atolls the current flows gently to the west, in March and April; and in the space between the equator and latitude 4° or 5° south, it runs east-north-east. It extends a considerable distance on both sides of the meridian of those islands, with a velocity of from 40 to 56 miles per day. In the Equatorial Channel, and among the Southern Atolls, the current generally flows east in October, November, December, and January; while during the same season it flows to the west between the Maldives and Ceylon; and between latitude 3° and 5° north, in the meridian of Point de Galle, it has a velocity of from 20 to 35 miles per day, but this velocity decreases on approaching the equator.

Coast of Malabar.—In November the current is generally weak and uncertain on this coast, except in the vicinity of Anjengo, between which and Cape Comorin, a strong south-easterly current is sometimes observed. In January, on the contrary, the set of the current is northerly. From November to March, when the weather is generally fine, the current along the coast is scarcely perceptible; but between the Laccadive and the African coast it flows with the monsoon south-west, and has a velocity of from eight to twelve miles per day. In March and April, when strong north-west winds prevail, there is generally a powerful south-east current along the Malabar coast, while among the Laccadives, and to the westward, the prevailing direction is south and south-west. In May the southerly current sets along the west coast of India, with a mean velocity of from five to seven miles per day, which is increased on approaching Anjengo and Cape Comorin; but it sometimes happens that in May and June the current is hardly perceptible. When in these months the wind veers to the south, it causes a northerly current along the shore, which is especially observable near the entrance of Bombay harbour; but in the open sea, during the same months, the current generally sets to the eastward. In July, when the rivers of the peninsula are swollen by the rains, causing great floods, the current flows stronger to the south. At the entrance of Bombay harbour, however, a southerly current is seldom observed, the freshes neutralising these partial influences. The regular flood and ebb tide counteracting each other; but south of Bombay the current flows at the rate of from 10 to 15 miles per day, increasing to 18 or 20 miles towards the south part of the peninsula. This southerly current continues during August and September, and is strongest between Cochin and Cape Comorin, where, in August, September, and the early part of October, it is often from 25 to 30 miles per day. When the river floods are very powerful, the current is usually somewhat distant from the shore; between Calicut and Anjenga, it has been observed in a south-south-east and south-east direction, with a velocity of from one to one and a-half mile per hour. To the westward of the Laccadives, in the open sea, the current flows to the east in July and August, and south in September and October.

Persian Gulf.—The Persian Gulf is situated beyond the limits of the monsoons, but from the position and nature of the neighbouring countries, periodical winds prevail, which blow up and down the gulf at different seasons, these produce corresponding drift currents, which run into the gulf from May to September, and out of it during the remainder of the year.

Red Sea.—The currents of the Red Sea appear to be entirely governed by the winds; during the prevalence of southerly breezes they run to the north, and with northerly winds to the southward: it is probable, also, that they increase with the strength of either, little or no current being perceptible during the prevalence of light variable airs, previous to the setting in of the south winds. In the vicinity of Jiddah harbour the current runs, in the different seasons, at a rate of from one to one and a-half mile per hour. To the westward of the Laccadives, in the open sea, the current flows to the east, depending on the direction of the wind, which, when strong, causes them to run at the rate of from 20 to 40 miles a-day. From May to October, in the northern part of this sea, the water is two feet lower than in the other months of the year. This is caused by the influence of north winds, which at this season prevail through the whole extent of the sea, and cause a continued current to set through the strait into the Gulf of Aden. From October to May, when the south winds prevail, in the lower part of the sea, these currents change their direction, and flow back with rapidity; the whole body of water having no means of escape, then collects itself in the northern part of this sea, which becomes generally elevated.[2]

East Coast of Africa.—From the equator, along the east coast of Africa, to Cape Guardafui, and thence along the Arabian coast to Ras al Had and the coast of Persia, a north-easterly current commences with the south-west monsoon in March and April, and continues till September or October, when the north-east monsoon begins and produces a south-west drift current.

Mauritius and Rodriguez.—The existence of currents flowing from east to west in the vicinity of these islands is noticed by Rennel and Horsburgh, and has been fully confirmed by the late Prussian navigators. The causes of this current are found in the trade winds, on the southern extremities of which it they occur; and a striking example of their effect was experienced during the Rodriguez hurricane in 1843, when the *Victoria* was wrecked on the reefs to the eastward of Rodriguez. The vessel went ashore on the 7th April, three days after the hurricane had passed over the island, and, about a month afterwards, part of the wreck was picked up on the south-east coast of Mauritius, 500 miles to the westward; which indicates a current running at the rate of about 10 miles per diem.[3]

Cape Counter Current.—This current is noticed in the table of currents in the Atlantic Ocean (p. 4), as carrying the waters repulsed by the bank of Agulhas back into the Indian Ocean in high latitudes. In the vicinity of the cape its mean velocity is about 50 miles per day. Its easterly course has been observed, according to Rennell, as far as longitude 65° 15′ east; and from the circumstance of being favoured by the prevailing westerly winds, it is extremely probable that its influence extends to the shores of Australia.

South-west Coast of Australia.—According to Flinders, the current divides, near Cape Leeuwin, into two streams, one of which flows north, and the other east, along the coast of Australia. In May and December, he found, between Cape Leeuwin and King George Sound, a velocity of 27 miles per diem; but it often decreases to 16 and 13 miles east.

Molucca, Timor, and Arafura Seas.—The current prevailing in these seas appears to be the same in both monsoons, except that, during the westerly monsoon, there is a set of nearly two miles an hour to the eastward, between the south-east extremity of the Island of Timor and Port Essington.[4] During the easterly monsoon this set is scarcely perceptible. The current in these seas which, in some parts—the Ombay passage, for instance—sets constantly to the south-west, at the rate of from two to five miles per hour, is evidently caused by the body of water driven in from the North Pacific by the easterly winds which prevail there.[5]

TEMPERATURE AND OCEANIC WARMTH EQUATOR.

The observed temperatures indicated on the line of the warmth equator on the chart, show that the maximum heat of the waters of the Indian Ocean (87° 40) occurs in the Arabian Sea, between the Strait of Bab-el-Mandeb and the coast of Hindostan. This result we owe to the recent observations of M. T. Philippi,[6] whose measurements, as M. Mahlmann observes, "afford a new but by no means an unlooked for proof of the high temperature of the basin of the Red Ocean." M. Philippi's observations extend from Suez to Calcutta, and show a remarkably regular increase of temperature in the Red Sea in the direction from north to south.

Having, in this chart, completed the delineation of the oceanic warmth equator round the globe, it may be interesting to trace its course through the principal divisions of the ocean; and, commencing at the eastern side of the Pacific, we find that it forms an irregular curve, proceeding westwards from the Bay of Panama, north of the Galapagos Isles, and gradually approaches the terrestrial equator, till, at about 150° west, it crosses it. In the western part of the ocean, it crosses the line and runs south of it till it attains its maximum on the northern shores of Papua, at which point it nearly coincides with the terrestrial equator. It then takes a sudden turn towards the south, and, passing through the Indian Archipelago and the Strait of Malacca, in the Bay of Bengal by the shortest route, thence it continues nearly due west till it reaches the eastern coast of Africa, near the Strait of Bab-el-Mandeb. On the western coast of Africa, it leaves the Gulf of Guinea, north of the terrestrial equator, and maintains a north-westerly course along the shores of South America, and through the Caribbean Sea, attaining the maximum temperature in the Gulf of Mexico. It then approaches the terrestrial equator at its extent, the line of greatest oceanic warmth lies in the Northern Hemisphere, at an average distance of about five degrees from the equator of the globe; while its average distance from the line, during the other fourths of its progress, is in the Southern Hemisphere, to about three degrees; and that it coincides with the equator of the globe only at the points where it crosses, and at the Island of Papua.

The maximum temperature of the three great divisions of the ocean is thus found to be—			
Pacific Ocean,	Latitude 0° 0′	Longitude 135°	E. 88.° 52
Indian Ocean,	" 9 55 N.	" 59 52′	E. 87. 40
Atlantic Ocean,	" 28 N.	" 88°	W. 88. 52
	Mean,		88. 15
The mean temperature of the equator of heat of the atmosphere is,			82. 4
Showing a difference in favour of the heat of the ocean of			6.° 11

On comparing the line of oceanic with that of atmospheric temperature," we find that the latter follows, in general, a more northerly course, about seven-tenths being in the Northern, and three-tenths in the Southern Hemisphere, and that the position of each, in reference to the terrestrial equator, bears a considerable resemblance to the other, the greatest difference being observable in the vicinity of the coasts of the Indian Archipelago and on the western coast of Africa, where the equator of atmospheric temperature is much farther north, and in the Caribbean Sea, where it is much farther south than the other. These differences may be satisfactorily explained by the position of the land in the places referred to, the continent of Africa having a tendency to raise the equator of atmospheric temperature towards the north in the one case, and that of South America to incline it towards the south in the other.

[1] See Tables of Six Months Passages.—Nautical Magazine, September 1845.

[2] Nautical Magazine, 1844, p. 265.

[3] The great ocean was crossed by Mr. Wise in September 1843, and adopted by Her Majesty's Government in June 1845; his plan includes the Island of Labuan, on the coast of Borneo, as an intermediate station. This island, which has since been ceded to Great Britain, exports a considerable quantity of excellent coal.—*Report by Mr. Wise*, 1845, p. 105.

[1] All these limits are reduced to the same valuation of the year—they are subject to considerable alterations at the different seasons.

[2] That part of the coast of Australia from Cape York to Cape Van Diemen, and extending as far to the south as the parallel of 12° south latitude, may be said to lie within the limit of the east and west monsoons, as at a short distance from the coast these particular winds will be found to blow with great regularity. Near the land, the easterly monsoon sets in between the 1st and middle of April, and the westerly monsoon in October, and sometimes not until November. At a greater distance from the land they are probably more regular, as the changes of the monsoons are said to take place about the first week of April and October. In 1835, the westerly monsoon set in at Port Essington in the first week of November; there had been no rain before that. Captain Wickham.—*Surveys of the Straits*, App. 58. Recent observations have shown that the westerly monsoon extends to the eastward in the Pacific, as far as the Island of Tahiti.

[3] From the experiences of Captain Sullivan at Mangaia and Tahiti, as well as observations of other navigators, there is reason to believe that tornadic gales are prevalent in the Pacific as well as in the Indian Ocean.

[4] See Notes on the Horsburgh, Meteorological Division, Chart 2.

[5] Mr. Pellington says he has not been able to draw them below latitude 11° north.

METEOROLOGICAL CONDITIONS OF THE INDIAN OCEAN.

For the reasons stated in the introductory note, we have pointed out on this chart the limits of the winds and storms of which the Indian Ocean is the theatre. We shall now briefly describe the extent of these different regions, referring, for an explanation of the various phenomena, to the notes accompanying the chart of the Atlantic Ocean, Meteorological Division, No. 2; on which we have also given enlarged diagrams and descriptions of the Rodriguez Hurricane, and the Calloden Storm.

South-East Trade Wind.—As shown by the coloured lines on the chart, the south-east trade or passage wind extends, in the southern part of the ocean, from about latitude 10° to 28° south, within which limits it blows powerfully, and with great steadiness, from April to October, when it extends to within a few degrees of the equator. After this date, when the sun enters the Southern Hemisphere, this force and regularity gradually decrease, and, as the solar heat increases, it altogether disappears, or leaves the vicinity of the equator for latitude 10° or 12° south, which may be considered as its northern limit during the hot season, at which time its southern limit is extended to 29° or even 30° south. South of the zone of the trade winds, we find the district of the north-west winds, which prevail nearly in the same latitudes in the Atlantic and Pacific Oceans.

Monsoons.—The northern part of the Indian Ocean is the region of the monsoons. They prevail over a tract extending from latitude 7° or 8° south of the equator, to the countries of Asia on the north; and from the Channel of Mozambique and the Red Sea on the west, to the shores of Australia[1] and the China Sea on the east.

[1] Sailing Directions, Moresby and Elwon's Chart of Red Sea; Lieut. Wellsted, Geographical Journal, vi, 32.

[2] Nature and Course of Storms, p. 12; Nautical Magazine, 1844, p. 825.

[3] Nautical Magazine, 1844, p. 1, 265.

[4] Observations on temperature made on board the steamship *Bentinck*, from 26th April to 17th May 1846.—*Monatsberichte der Gesellschaft für Erdkunde zu Berlin*, 1845, p. 158. [5] See Meteorological Division, plate 1.

PHYSICAL CHART

OF

THE PACIFIC OCEAN.

FOUNDED ON THE

OBSERVATIONS WHICH HAVE BEEN MADE FROM THE TIME OF MAGALHAEN TO THE PRUSSIAN NAVIGATORS.

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I. INTRODUCTION.

This immense expanse of water, bounded on the one side by Asia, the Philippine Islands, and Australia, and on the other by America, extends from the Arctic to the Antarctic circle, through a space of 133 degrees of latitude. It was unknown to Europeans till the year 1513, when it was discovered by *Vasco Nunez de Balboa*, from the summit of a mountain near the Isthmus of Panama. *Magalhaes*, who sailed from America to the Philippine Islands,[1] bestowed upon it the name of PACIFIC, in consequence of the calm and delightful weather he experienced while navigating its surface.

It is usual to consider this ocean as divided by the equator into the North and South Pacific; but, for facility of reference, we shall adopt the arrangement which divides it into the three following parts:—(1) The *Northern Pacific*, between Behring Strait and the Tropic of Cancer; (2) *Equatorial Pacific*, from the Tropic of Cancer to that of Capricorn; and (3) the *Southern Pacific*, from the Tropic of Capricorn to the Antarctic circle. *Duperrey* made the first attempt to collect the existing observations on the currents of the Pacific Ocean. His beautiful work,[2] which, however, only extends to the parallel of the Sandwich Isles, and does not comprehend the Northern Pacific, has served as a model for mine, but only as a model; for I have had an opportunity of making many additions to Duperrey's delineations, and of extending and completing them. Among the most important of these may be mentioned the more accurately determined course of the Peruvian Coast Current of cold water, which, from the discoverer of its thermic qualities, is called Humboldt's Current.[3] I have shown on the chart that the southern part of the Antarctic Drift Current, in the parallel of the Island of Chiloe, strikes on the South American coast, and splits into a southern and northern current, of which the one forms the Cape Horn Current and the other the Peruvian Current. Through the voyage of Captain Harnesen, from Guayaquil to Valparaiso, in August and September 1827, and the observations then made on the direction and velocity of the ocean currents, as well as on the temperature of the air, I had formed the opinion that this cold current spreads itself out into the open ocean, round the group of the Gallapagos Isles, in the parallel of Punta Pasina; for the current which, after leaving the Isla Santa Clara (at the mouth of the Rio de Guayaquil), was northerly, turned to a westerly direction, and continued so for five days, when its general direction was observed to be north 50° west, and the medium velocity amounted to eighteen miles in twenty-four hours. Outside the current, the temperature of the air was 76°.1; inside of the same, according to the observations made from the 26th to 31st August, the medium was 68°.72, maximum 69°.88, minimum 63°.86. So remarkable a depression of the temperature of the air in a tropical region, where the water in the open ocean, free from currents, has a temperature of at least 80°, can only be ascribed to the influence of the Peruvian Coast Current of cold water, which operates most perceptibly westward of the meridian of the Gallapagos Isles to about the parallel of latitude 7° 20′ south. Further towards the west, however, it gradually loses its cooling power, although it may still be remarked at an astonishing distance, even under the line of greatest ocean heat; for whilst this, about the meridian of Guayaquil, has, according to Humboldt's observations, a temperature of 84°.74, and in the meridian of Acapulco, in latitude 7° north, according to Beechey's[4] observations, a medium warmth of 85°.46, it amounts in the meridian of San Francisco, 44 degrees from the Peruvian coast, only to 81°.68, according to Meyen's observations.[5] On comparing these with the observations which have been made in the above-named voyages of the Prussian Seehandlungs vessels, from the American coast to the Sandwich Islands, we ascertain the direction of the stream between the meridians of longitude 98° and 118° west. The occasional easterly course of the current, of which other parts of the ocean afford many remarkable examples, must here be considered as an anomaly which can only be explained by further thermometric observations. For we find, in the journal of the *Mentor*, that when it had passed the parallel of latitude 10° south, instead of 80°.6 mean temperature, which might have been expected, the temperature of the air at noon was observed to range from 74°.7 to 79°.16 (the last under the terrestrial equator), and the maximum 80°.24, in latitude 3° 29′ north. In the same manner, on the first voyage of the Princess Louise, under the command of Captain Harnesen, in the same region, the temperature was never observed to have reached 80°.6.

Within the zone between latitude 10° south and 4° 30′ north, the temperature of the air fluctuated between 75° and 79°, and the mean, according to sixteen days' observations, amounted to 77°.18.

Lastly, Meyen, on the second voyage of the Princess Louise, between the parallel of 10° south and the oceanic-warmth equator, never found the temperature of the sea, on the surface, above 80°.78. The mean of thirty-five observations amounted to 78°.35, the minimum 75°.2.

These facts seem to entitle me to carry the course of the Peruvian stream from the point where it leaves the American coast, westward, in the direction marked on the chart: and I have had the satisfaction to see these views confirmed by the observations of Captain Fitzroy. This talented officer, to whom the hydrography of both oceans is so much indebted, observes, in a preliminary notice of his great expedition, the remarkable currents which are found in the vicinity of the Gallapagos Islands. "In some places," says he, "they run three, four, or even five miles an hour,[6] generally, but not always, to the northwest. On one side of an island the temperature of the sea is sometimes found to be near eighty, while on the other the water is at less than sixty degrees. These striking differences may be owing to the cool current which comes from the southward, along the coast of Chile and Peru, meeting a far warmer stream from the neighbourhood of the Bay of Panama."

"A knowledge of the currents and winds of the Pacific Ocean," says Mr Redfield, "will, I am convinced, serve to remove all mystery and all doubt from the once vexed question of the first peopling of its islands from the Asiatic continent, in spite of the long urged objection of the opposition of the trade winds. A case is still recent where the wreck of a Japanese junk was drifted the entire distance to the Sandwich Islands, with its surviving crew, thus completing nearly half of the great circuit of winds and currents in the North Pacific. But we shall find an additional means of transport near the equator, which is afforded in the north-west monsoon of the Indian and Pacific Oceans, and which, according to my inquiries, is found to extend, at one portion of the year, as far eastward as the Society Islands, or more than half the distance from the Indian Ocean to the coast of South America."

The distances mentioned in the chart and notes are reckoned in nautical or geographical miles, sixty of which are equal to a degree of latitude.
The temperature is uniformly given in degrees and decimal parts of Fahrenheit's scale,[7] and the longitude is reckoned from the meridian of Greenwich.

II. NAVIGATION OF THE PACIFIC.

Professor Meyen has communicated the following information on the routes by which the commerce of the Pacific is conducted:—

1. TRACKS FROM AMERICA, &c. TO ASIA.

Examples Coloured RED *on the Chart.*

There are two lines of communication between South America and the southern part of Asia, the one or the other of which is chosen, according to the object of the voyage, or other circumstances. Ships bound from Chile, Callao, or Guayaquil, direct to China, usually steer in a straight line to the Mendana Isles (the Marquesas of the Spaniards, and the Washington Islands of the Americans). In this part of the voyage they are assisted by the south-east trade winds; they then pass to the south of Gilbert Islands and the east of the Pelew Islands;[8] their direction is afterwards determined by the direction of the monsoons in the China Sea. They either sail through the Strait of S. Bernardino, and avail themselves of the south-west monsoon, or north of the Philippines, through the Bashee Isles, and here cut the north-west monsoon. If the navigator on this last route does not exactly observe the required latitude, and approaches the coast of China even a single degree too far to the south, the voyage may be prolonged several weeks. Ships which, on this great route (one of the longest, though the most pleasant) intend to take in fresh water or provisions, sail to the Sandwich Islands, and avail themselves as soon as possible of the north-east trade wind, which blows much stronger, and with greater regularity than the south-east trade. On this route, ships also avoid the frequent calms which prevail in the vicinity of the island groups in the Southern Hemisphere, and add considerably to the length of the voyage. On the voyage in the north-east trade, which ships can always make in a straight direction, they sail to the north of the Sandwich Islands, far above the meridian of the Mariana Islands. From the Sandwich Islands the voyager prefers a course in 12° to 15° north latitude, where he is more certain to find a strong trade wind than in the higher latitudes, especially above 20°; afterwards, he must steer a more or less northerly course, according to the monsoon, in order to arrive at the latitude of Macao This route is nearly the same as that formerly followed by the Spanish galleon on the voyage from Acapulco to Manila, to the latitude of the Sandwich Islands, where it usually anchored, and afterwards steered to the Marianas, where it came to anchor at Guam or Guahan, in order to communicate the instructions of Government, and take in fresh provisions. Afterwards the galleon directed its course eastward of Manila to Cape Espiritu Santo, on the Island of Samar, near which it was once taken in a celebrated engagement by Lord Anson.

2. TRACKS FROM ASIA, &c. TO AMERICA.

Examples Coloured BLUE *on the Chart.*

On the voyage from India to South America, which is generally made during the south-west monsoon, ships keep to the north of the limits of the north-east trade wind, which is usually met with only in latitude 28° and 29° north. Here they are sure to find the so-called western trade, with which they sail to the coast of California, in order to correct their longitude; but if this be not necessary, they direct their course straight to the place of their destination, cutting the trade wind only at an acute angle. Even those ships which intend to Peru and Chile, usually take the same route; they then sail southwards till they reach the south-east trade wind; they must cut this towards the west, and seek the south-westerly winds in latitudes 26° to 28°, with which they reach the coast, and then sail to the place of their destination. Ships sailing from China during the north-east monsoon, must take their course in the Southern Hemisphere, where the voyage is very dangerous, on account of the numerous islands and coral banks through which they must sail. On reaching the meridian of New Caledonia and New Zealand, however, they may hope for a speedy termination to their voyage, by the assistance of the constant westerly winds, and probably this track will in future be generally adopted. This route may also be taken from Port Jackson and Van Diemen's Land on the voyage to Europe, round Cape Hoorn, as was lately done by the brig Arethusa, Captain Boulton, who arrived at Cape St John (north-east point of Staaten-Land) in forty-six days from Van Diemen's Land.

3. STEAM NAVIGATION IN THE PACIFIC.

Mr Wheelwright, in detailing his efforts to establish navigation by steam along the coasts of Peru and Chile, says: "The coal mines in Talca[9] are every day improving in quality, and the quantity is unlimited; in fact, the whole southern country is nothing but a mine of coal. It would be difficult to form an estimate of the value of steam on this coast. On my recent return from Guayaquil to Lima (in the steamer), which occupied five days, I had an opportunity of observing it. One vessel sailed four weeks before us, and was thirty-six days. Another Baltimore clipper also sailed from Guayaquil a few days before us, and was twenty-five days, which I consider the average passage of ships sailing from Guayaquil to Lima. From Arica to Cobija we employ two days. A ship which sailed from the former port we passed on the passage; she finally arrived in twenty-two days. These are every-day and most common occurrences, and such extremes of sailing ships versus steam-ships can be found on the Pacific."

III. CURRENTS OF THE PACIFIC OCEAN.

1. PERUVIAN COAST, OR HUMBOLDT'S CURRENT.

The following luminous and interesting description of this current is abridged from a manuscript memoir by the discoverer of its thermic proportions, A. VON HUMBOLDT:—

"As the existence and general direction of the Gulf Stream has been known, by its temperature, to European navigators for a century past, so also in the Pacific Ocean the existence of a great ocean current, from south to north, and north-north-west, has been observed since the time of the earliest intercourse between Chile, Lima, and Guayaquil; but the low temperature of this current, and its important influence on the coldness of the Peruvian coast, which was erroneously ascribed to the vicinity of the snow-capped Cordilleras, were, on my arrival on the shores of the Pacific, totally unknown.

"In the year 1775, Franklin expressed the hope that philosophers would yet discover cold currents in the ocean, conveying water from higher to lower latitudes, as he had shown that the Mexican Gulf water, flowing from lower to higher latitudes, communicates to them a part of the tropical heat of the Azores, and even of the Cantabrian Sea. Almost thirty years passed away before this hope of the great man was fulfilled, since, between La Condamine's expedition and my own, that part of the world was explored only with a view to astronomical and astronomico-geographical researches by Ruiz and Pavon, as well as by the companions of Alessandro Malaspina. At the distance of eighteen months' travel from the shores of the Atlantic Ocean, I had a great desire to see the Pacific, and to continue in the Southern Hemisphere those observations on the temperature of the sea which had so agreeably occupied me in the Northern. The first concern of a traveller on arriving at the sea coast, after a long absence in a mountainous country, is to observe the height of the barometer, and the temperature of the water. I was occupied with the latter in a district between Truxillo and Guanaco, near Callao de Lima, and on the voyage from Callao to Guayaquil and Acapulco, on a tract of the Pacific Ocean of more than 600 miles in extent, when, to my great surprise, I found that the temperature of the surface of the sea under latitudes where, outside of the current, the temperature ranges from 78°.8 to 83°.3, was at Truxillo, at the end of September, 69°.8; and at Callao, in the beginning of November, 59°.9. The temperature of the air was in the first period, 64°.04, in the second, 72°.86 and thus (which it is of importance to remark) 12°.6 warmer than the ocean current.

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[1] The probable track of Magalhaen's squadron is given on the chart according to Kruzenstern.
[2] Carte du tour-monde des mers à la surface de tout dans de Grand Océans Austral; Par le Capitaine Duperrey. Paris; 1821.
[3] See Meyen's Reise um die Erde, ii. bd., p. 32, and meine [Berghaus'] allgem. Länder und Völkerkunde, i. bd., p. 354; Geographischer Almanach auf das Jahr, 1832, p. 260.
[4] Beechey found the belt of warmest water in longitude 100° west, between the equator and latitude 14° 22′ south.
[5] Meyer's Reise um die Erde, ii., p. 24.
[6] Journal of the Royal Geographical Society, vol. vi., p. 333.
[7] The original observations on temperature having been generally reckoned in degrees and parts of the centigrade scale, have, when reduced to that of Fahrenheit, lost the character of round numbers than in many cases they were intended to express.
[8] See the southern, as long route from South America to China, on the chart.
[9] Talca is situated in latitude 35° 26′ south, longitude 70° 54′ west.
[10] Silliman's American Journal, vol. xxiii., p. 382.

PHYSICAL CHART OF THE PACIFIC OCEAN

OR GREAT SEA (MARE PACIFICO).

Showing the CURRENTS & TEMPERATURE of the Ocean THE TRADE ROUTES &c.

Founded on the observations which have been made from the time of Magalhaen to the Prussian Navigators.

Extended from the Original Designs of

PROFESSOR BERGHAUS, BERLIN.

BY A.K.JOHNSTON, F.R.G.S.

NOTE

At the point marked Y★ off the coast of California on the 24th March 1813, the American Brig Forester fell in with a Japanese vessel, which having sailed from Osaka in Japan, had in a storm on the coast lost mast and rudder, and become the sport of the waves for 17 Months. This fact as well as that of the wreck of a Japanese junk having floated to the coast of Kodiak demonstrate (according to Krusenstern & Kotzebue) the easterly direction of the North Pacific Drift Current.

Longitude East from Greenwich

Longitude West from Greenwich

Arctic Circle

Tropic of Cancer

Tropic of Capricorn

Antarctic Circle

EQUATOR

ASIA

CHINA

MANTCHOURIA

Yedo

Japan

Kurile Isles

Kamtchatka

Sea of Kamtchatka

BERING SEA

Aleutian Isles

NORTH AMERICA

North West Coast

OREGON

California

MEXICO

Florida

Bahama Is

CUBA

WEST INDIA ISLES

Jamaica

HAITI

CARIBBEAN SEA

Mexico

Acapulco

Panama

NEW GRANADA

Galapagos Isles

EQUADOR

PERU

Truxillo

Lima

Callao

Valparaiso

SOUTH AMERICA

Canton

Formosa

Philippine Is

Manilla

Luzon

Palawan

Sooloo Is

Mindanao

BORNEO

CELEBES

Gilolo

Ceram

Timor

Arafura Sea

NEW GUINEA

New Britain

Solomons

Louisiade

Torres Strait

Gulf of Carpentaria

NEW HOLLAND

NEW SOUTH WALES

AUSTRALIA

SYDNEY Albert Jackson

Melbourne

Adelaide

Van Diemens Land

NEW ZEALAND

Ladrones

Marianas

Pelew Is

Carolines

Marshall Is

Gilbert Isles

Fidjee Is

Friendly or Tonga Islands

Navigator Is

Cook Is

Society Islands

Low Islands

Marquesas Is

Mendaña Isles

Galapagos Isles

Bonin Is

Majicosima Is

Loo Choo

Kurile Is

Aleutian Isles

Sandwich Islands

Origin of the Peruvian Coast Current of Cold Water

Probable limit of Drift Ice

Explanation of the Colours

Tracks from American &c. towards Asia ——

Do from Asia &c. to American &c. ——

Do between different parts of America ——

Final limits of the Currents ——

Temperature of the Surface of the Ocean, in degrees & parts of Fahrenheits Scale (75.56) &c. ——

Oceanic warmth, Equator ——

EXPLANATION OF THE SIGNS &c

Voyages of the Royal Prussian Seehandlungs Vessels

Voyage of the Mentor in 1825

Princess Louisa in 1826-8

Do 2d Voyage in 1831

Do 3d Voyage in 1833

Ship Christian Voyage to Valparaiso in July & return to Europe in August 1827.

Place of the Ship at Noon each Day.

Direction of the Currents & of Do

Anson, Sharp, Byron	1743-1745	Wallis	1767
Carteret, Hunter, Vancouver			1790
Cook in all the 3 Voyages	1768-1778		
Bougainville's	1768	Pernse	1785
Laperouse	1785-1787		
Marchand	1791		
Meares	1788		
D'Entrecasteaux	1793		
Butler	1794		
Hagen	1796		
Broughton	1795-1796		
Fears	1796		
Surville			
Krusenstern	1804-1805		
Golownin	1811		
Kotzebue in both Voyages	1815-1829		
A.Erman	1829		

Flinders	1798-1803	P.P.King	1818-1821
Wasselieff			1820
Freycinet	1819-20	Lortigue	1822
Duperrey			1823-24
Bougainville			1824-26
Basil Hall			1817, 1820-22
Beechey			1825-28
Lütke	1826-29		

The Soundings of Ships are to be reduced to the Level of the Sea, & allowed their Drift

Fathoms 1835

Allan 1834-35

Abbreviations

Jan. January. Feb. February. Mar. March. Ap. April. M. May. Jn. June. Jl. July. Au. August. Sep. September. Oct. October. Nov. November. Dec. December.

A.I. Floating Islands of Ice & Icebergs as on the chart of the Atlantic Ocean

The foregoing list supplies a reference to the principal sources from which our knowledge of the Currents of the Pacific Ocean are derived. The original journals of the Prussian Voyagers were furnished by the Privy State. Minister M. Rother, and the returns of temperature of the Peruvian Current of Cold Water were kindly communicated in M.S. by the discoverer, Baron A.von Humboldt. The indications of temperature near the Galapagos Is are given according to Capt. Fitzroy, and those in the Southern part of the Equatorial Zone, from E. to W. according to Duperrey.

Engraved by W.& A.K.Johnston.

William Blackwood & Sons, Edinburgh & London.

"Thus the air could not possibly have cooled the water; and without having at that time an intimate knowledge of the climate of Peru, or of the period when the 'garua' prevails, I stated at Truxillo, on my first arrival on the coast, the opinion which has since been confirmed by many voyagers, namely, that the Peruvian stream is a polar current, which, flowing from higher to lower latitudes, follows the sinuosities of the coasts in a north-north-west direction, and that the perceptible amount of cold which is felt in the tropics, a few feet above the surface of the ocean in the so-called Desert of Lower Peru, is owing to the low temperature of the sea, and the interrupted action of the sun's rays during the period of the garua. As often as I could ascertain the temperature of the water at Callao in October and November, it was found to be between 59°.9 and 60°.8—at night scarcely 0°.7 colder than by day; only once it sank in a few hours to 59° and 58°.55, when (which is characteristic of this tranquil part of the Pacific, and considered by many of the inhabitants of the shores as the consequence of a submarine volcanic movement) with the clearest sky in a perfect calm, an immensely high and hollow breaker suddenly began to dash upon the granite coast.

"Apparently this last reduction of the temperature to 58°.55 arose from the same cause by which, according to my ideas, the water over a sand-bank is cooled. By the deep, perhaps volcanic, movements of the ocean, the lower stratum of water is mixed with the upper, arriving, as it were, on the plateau of a submarine island, as by pressure they ascend upon a sand-bank. From the beginning of November till the end of December, I observed the temperature gradually increasing; it rose to 69°.8, and the rapidity of this increase was afterwards fully made known by the researches of my friend Duperrey in 1825. On the 25th December 1802, I sailed from Callao to Guayaquil, in search of a ship which might carry me to the western coast of Mexico. On this whole voyage I had an opportunity of observing the extension of the cold current towards the north-west, and the remarkable influence which it exercises on this, the most westerly point of the South American coast, between Punta Parina and Cabo Blanco. The configuration of the Peruvian coast affords two points; first under the 18th and then under the 5th degree of latitude, in the most concave and the most convex part of its curve, points which correspond with the convexity of the Cape de Verde, and the concavity of the Gulf of Biafra, on the western coast of Africa. These turning points of the west-coast, the one to the north, lies in the Southern, and the other in the Northern Hemisphere, modify, by the position of the land in reference to the ocean and the prevailing winds, at once the ocean currents, the climate, and the character of vegetation. In the New World this influence of the western direction of the coast, and form of the continent, is so much the more powerful since here (and here alone) it runs almost parallel with a high mountain chain (that of the Andes) in its vicinity. The following notes contain the facts and opinions which first presented themselves to me as I recorded them at the time, on the ocean. The current flavours every voyage on these coasts, from south to north, to such an extent that one may easily sail in four or five days from Callao to Guayaquil, and in eight or nine days from Valparaiso to Callao (a distance of more than a hundred miles), on the return up the current, several weeks, and in some cases even months, are required. On my voyage, the increase of temperature of the cold current, as I drew near the equator, to 4° 30' south latitude, was not considerable, scarcely amounting to 2°.16. As long as we were in the current the temperature of the sea was 69°.8 to 72°.14. The fear that, notwithstanding the great depth of the sea on the Peruvian coast, the vicinity of the coast itself might have modified the climate, was soon dispelled, when in the open sea, one hundred or one hundred and twenty miles from the continent, the temperature of the water was found to be still 69°.8, as between Callao and the Island of San Lorenzo. The current turns suddenly towards the north-west, at Cabo Blanco, and supposed, in the course of a few hours, from water the temperature of which amounted to 68°.72 and 69°.08 into that of 80°.6—a difference of 12 degrees.

"Is the origin of the cold current to be sought for near the outlet of Magellan Straits, at Cape Pillar, where in November the temperature of the sea scarcely amounts to 41° or 42°? An intelligent Spanish seaman, Don Josef de Moraleda, who commanded the ship in which I made the voyage from Callao to Guayaquil, assured me that, in the Archipelago of the Islands of Chonos and Huaytecas, the coasts of which he had explored, he had found the temperature of the water to be 48° or 49°, and that it increased to the north to be very slow. On the surface, it only moved at the rate of from three to five tenths of a mile per hour, as in a drift current; but careful observations with the lead had shown, that at a depth of from twelve to fifteen fathoms, the current in the same direction is much stronger. The agitated parts of the water, flowing from the warmer layers, may maintain the low temperature of higher latitudes, and remain at a depth corresponding to their specific gravity.

"From Valparaiso and Coquimbo, but especially from Arica, north to Lima, the current at the strongest runs from twelve to fourteen, and sometimes even eighteen miles in twenty-four hours.

"It is observed in this, as in all other ocean currents which strike against a mainly mountainous shore, that the impediment hastens its course, and, consequently, the maximum velocity is found along the coast. This force of the current is the cause why ships which, at the time of the garua, sail from Quilca to Callao de Lima are unable, for several days, to obtain any observations for latitude; and, prevented by the fog from ascertaining their position on the coast, they are often, in their great disappointment, carried past the harbour of Callao to Huacura and Guarney, while, according to log-reckoning the voyager believes himself to be still to the south of Callao. The mist and fog are most dense between Pisco and Lima.

"The voyage against the stream from north to south is as toilsome, that in sailing from Paita or Callao to Valparaiso or San Carlos de Chiloe, ships, in order to avoid the current, take a course more than eight degrees to the westward of Juan Fernandez; and a Spanish frigate, the Santa Rosalia, on the voyage from Paita to Valparaiso, was carried so far to the west, apparently by the Equatorial Current, as to touch Easter Island (Isla de Pascua or San Carlos of the Spaniards), longitude 109°.17' west. When the Peruvian Coast Current has reached its maximum, between Arica, Quilca, and Lima, it flows to the north-west. Between Lima and Cabo Blanco, where it suddenly leaves the coast, and mixes with the general *Rotation*, or *Equatorial Current*, its mean velocity, according to my observations, was from seven to eight miles in twenty-four hours. The local condition of the coasts at this turning point, and their easterly bending, between Punta Parina and Cabo Blanco, form the chief source of an ocean current, with a temperature so low as 69°.08, are undoubtedly the causes of the greater warmth of the coasts of Guayaquil, and the totally altered condition of the atmosphere north of the Cerro de Amotape."

Twenty years after his return to Europe, Baron Humboldt had the satisfaction to see the truth of the observations first made by him in the eastern part of the Pacific, which led to the discovery of this cold current, and its influence on the climate of Peru, fully established by three eminently talented travellers—the French Captain Duperrey, the Danish Lieutenant Direkinck Von Holmfeldt, and the Prussian naturalist Dr Meyen, in their observations made during the years 1823, 1825, and 1831, in the most opposite seasons.

On comparing the mean value of the observations on temperature made at Callao with those under the same parallels in all other parts of the globe, Duperrey finds the following result, which places the phenomenon of the cold current of Peru in the clearest light:—

	Air.	Ocean.
The mean temperature under latitude 12° south, . . .	78°.94	78°.70
Do. at Callao de Lima, latitude 12° 3' south, 26th Feb. to 4th March 1823,	68 .36	65 .66
Difference, . . .	10°.58	14°.04

If, instead of the mean value of all the observations, we take those only which refer to the Southern Pacific, bounded on the east by the Peruvian coast, we find a still more remarkable difference. In this case the difference in the temperature of the air is 10°.28, and for that of the ocean 14°.40, in the harbour of Callao.

The following is the difference of the highest and lowest state of the thermometer for all the observations of Duperrey, in the Atlantic, Pacific, and Indian Oceans, as compared with that of Callao:—

	Maxima.	Minima.
Temperature of the air, ...	88°.80 .	19°.32
Temperature of the sea, ...	82 .42	19 .26

At Paita (latitude 5° 6'), Duperrey found the temperature of the current, between the 11th and 22d March 1823, always between 68°.90 and 7°°, mean 72°.93, whilst in the ocean, outside of the cold current, the mean was 80°.69.

Baron Direkinck, at the request of A. Von Humboldt, made a long series of observations on the Peruvian Cold Current in the years 1824 and 1825, the results of which coincide in a striking manner with those already stated. Humboldt observes, that in this table of the temperature of the ocean between Callao de Lima and the equator,[1] "the change from the temperature of the cold current to that of the adjoining sea, north of the parallel of Cabo Blanco, is very remarkable. Between the 4th and 5th April it rose from 71° and 72°, to 80° and 83°." "I found it [he remarks] about the same region change from 70°to 80° Fahr."

"Duperrey has given entirely new views on the origin of the cold current of the coast of Peru. By comparison of the observations of numerous voyagers furnished with chronometers, this experienced officer has shown that between the meridian of the South Cape of New Zealand and Pitcairn Island, a mass of water moves in an easterly direction of 30 degrees of longitude, in a *Drift* which is driven by melting ice and the prevailing south-south-west winds from the south pole—first towards the north-north-east, and then north-east, and lastly towards the east-north-east, when, meeting the coast of Chile, between Conception and Valparaiso, it divides (in a manner similar to that of the Equatorial Current on the Brazilian Coast, near Cape St Augustine), one part flowing south along the coast by the Island of Chiloe, the Archipelago of Chonos, and Cape Pillar, to Cape Horn, and the other northwards by Arica, Callao, and Paita, to Cabo Blanco.

"This view, embracing an immense extent of ocean surface, places at a distance of thirteen hundred geographical miles the origin of the Peruvian Cold Current, and increases a phenomenon of the Southern Hemisphere, which has so long occupied my attention, to the importance of that of the Gulf Stream of Florida, as shown by Rennel's researches, if followed upwards from the Agulhas Bank, at the Cape of Good Hope."[2]

2. EQUATORIAL CURRENT.

According to the careful observations of Duperrey, the current which flows from the Antarctic Ocean towards the coast of America, turns suddenly, at the distance of twenty-two degrees of longitude, from the continent, under latitude 20° south towards the west, in order to form the great Equatorial Current of the Pacific Ocean, which, in general, following the impulse of the trade winds, runs in a westerly direction. The calculation that the southern limit of this current coincides with the parallel of 20° south, while its northern border may be reckoned at about 24° north. So that the oceanic water moves in a westerly direction over a space of 50 degrees, or nearly the third part of the distance from pole to pole.

3. MEXICAN COAST CURRENT.

Passing over to the Northern Hemisphere, we find first the Mexican Coast Current, an alternating current which is occasioned by the monsoons of the coast. A. Von Humboldt first gave a description of this current; and Basil Hall and Beechey afterwards furnished contributions towards its elucidation.

4. FLEURIEU'S WHIRLPOOL.

I have named the current in the eastern division of the North Pacific Ocean Fleurieu's Whirlpool, after the learned hydrographer of that name, who has described Marchand's voyage, in a work which ranks in the highest class of modern nautical literature. The whirlpool is laid down from the observations of Marchand; and since it is not contradicted by the animadversions of Lütke, who sailed directly through its course, I have considered myself justified in laying it down provisionally.

5. CAROLINIAN MONSOON CURRENT.

The monsoons of the Indian and China Seas exercise their sway to the meridian of the Mariana Islands, and the middle of the Carolines. Here they engage in conflict with the trade winds, and occasion an alternating motion of the water, which I have called the *Carolinian Monsoon Current*. It flows with great velocity, especially in the western districts. However, it is remarkable that westwards from the Marianas, the Equatorial Current seems to be prolonged constantly, and not to be under the influence of the monsoon; but appears to be again active in the JAPANESE CURRENT, which is laid down on the chart according to the luminous description of Krusenstern.

6. PENJINSK OR PENSCHINSK CURRENT.

In that part of the North Pacific Ocean which we call the Sea of Okhotsk, known in Kamtchatka and Siberia only by the name of the Sea of Penjinsk or Penschinsk,[3] constant south-east and easterly winds blow in the months of June, July, and August, and easterly winds prevail throughout the whole year. In consequence of this, there are easterly currents of the ocean which flow in the direction of the coast. These are, according to the observations of Captain Meinikow, who, for eight years, was commander in Okhotsk.[4] Adolf Erman has favoured me with an abstract of his ship's journal on the voyage from Okhotsk to Tigil, which gave him an opportunity of verifying the animadversions of Minitzkoi. The track of Erman's voyage through the Pacific Ocean is that of Captain Hagemeister, from Sitka, by San Francisco and Tahiti, to Cape Hoorn, which is traced on the chart.

7. NORTH EQUATORIAL COUNTER CURRENT.

Between latitude 5° and 10° north, and between the meridians of 113° and 150° west, occurs the remarkable stream which I have called the North Equatorial Counter Current; and in the parallel of the Sandwich Islands, the entanglement of the easterly currents—two phenomena which the numerous observations of the Prussian navigators have established beyond a doubt.

Besides Freycinet, who was acquainted with the latter phenomenon, and Duperrey, who observed it in the Archipelago of the Carolines, Beechey also found it to the west of the Sandwich Isles; and Lütke has collected numerous facts proving the existence of this counter current, which is met with in the middle of the most powerful trade winds.

Meyen has attempted to explain it,[5] and I have given an opinion on the probable cause of this extraordinary phenomenon,[6] with deference, however, since a seaman of such experience as Admiral Lütke says that the observations are not yet numerous enough to warrant a general opinion in regard to it." [7] In this subject Mr Redfield makes the following remarks to me—

"The numerous archipelagoes of islands, and the extensive groups of coral reefs in the Pacific, serve to intercept the regular westerly progress of its warm intertropical current, and to determine more than one circuit of compensation and revolution in each hemisphere. This class of obstructions partly supplies the place of a continent, in creating separate basins of revolution for the currents of this vast ocean; and this is particularly the case in the South Pacific, where these obstructions are scattered over wide areas. Hence strong currents setting to the eastward have been found in various parts of the Pacific, below the latitude of 30°, moving in direct opposition to the influence of the strongest portion of the trade winds."

8. MENTOR'S COUNTER DRIFT.

In the Southern Hemisphere, about the Tropic of Capricorn, the observations which were made on board the Prussian Seehandlungs vessel Mentor, in the year 1823, indicate the motion of a current which is directly opposed to the great Equatorial Current.[8]

I have represented this remarkable phenomenon under the name of *Mentor's Counter Drift*, in order to call the attention of voyagers to its existence, and to recommend further observations upon it, but without being prepared to say, from those observations taken by themselves, that this drift stream is always easterly; although not only La Perouse and Kotzebue's animadversions, but those of Duperrey, and, in some measure also, the observations of Lütke on the 23d and 24th April 1827 appear to show that it is non-periodical.

9. ROSSEL'S DRIFT.

From the Friendly Isles, westward to New Caledonia and the New Hebrides, the Equatorial Current, which hitherto, with very little exception, has run uniformly westerly, takes a decidedly north-west and west-north-west direction, flowing into the Corallian Sea and Torres Strait.[9] This phenomenon is undeniably connected with the trade wind, in so far that the constant winds blow more from the south than from the east in these regions. It must be remarked, however, that in this isle-bedecked sea it is often interrupted. I have called this north-west stream Rossel's Drift, in honour of the learned admiral of that name, who, in the narrative of the Expedition of D'Entrecasteaux, first made its existence known.

NEW SOUTH WALES ALTERNATING CURRENT.—It has long been believed, and is still asserted,[10] that there is a constant current along the coast of New South Wales, depending on the great Equatorial Stream, and having a constantly southern direction. Certainly the animadversions of Flinders, King, and Oxley, favour this view, but the more numerous observations of Lieutenant C. Jeffreys have demonstrated that alternating currents are found here. "From the parallel of 28° south to the south of Van Diemen's Land," says the above-named observer, "the current flows during the summer months (i.e., from August or September, to April or May) as follows: From the land, to a distance of seven leagues to the south-west, one and a quarter mile per hour, in the space between seven-and-twenty leagues distant from the land towards the north-east, three quarters of a mile per hour, and in the winter in an opposite direction."[11] That these alternating currents depend upon monsoon winds is not to be doubted, although these reports do not distinctly refer to them.

IV. TEMPERATURE OF THE PACIFIC, AND POSITION OF THE OCEANIC WARMTH EQUATOR.

Mention has already been made of the line of greatest ocean warmth, and its position in the eastern part of the Pacific. At first I had made this line cut the terrestrial equator under 178° 40' of longitude, and carried it thence through the middle of New Guinea and the southern border of the Celebes; but a minute examination of Duperrey's observations has shown that the position of the oceanic warmth equator should be as it is represented on the chart. This line is, of course, only theoretical; it expresses the axis of a zone, in which the water of the ocean possesses a more or less uniformly high temperature. I find the position and temperature of this axis in the western part of the Pacific, and the contiguous Moluccu Sea, according to Duperrey's observations, as follows:—

Indication of the Position.	Latitude.	Longitude.	Temperature.
1. South of Gilbert's Archipelago, .	0° 26' S.	174° 50' E.	84°.74
2. North side of New Guinea, .	0 19	137 00	84 .76
3. Near the Island Waigiu, .	0 02	130 42	84 .74
4. In the Moluccu Sea near Ombay, .	3 06	124 28	84 .56

This uniformity of temperature, in a space of more than 50 degrees of longitude—*i.e.*, in the seventh part of the circumference of the earth—is no less surprising than its agreement with the observations of Humboldt on the coast of Esmeraldas and Choco, in the Northern Hemisphere. We may, then, without hesitation, state the mean temperature of the oceanic warmth equator in the Pacific Ocean to be 84°.74. Fahr.," or higher than that of the Atlantic; whence it is evident that the cause of the temperature under the meridian of 115° west longitude, being nearly 5 degrees lower than this, is to be ascribed alone to the cold water of the Peruvian Current. And thus we see that, as the Gulf Stream in the temperate zone pours warm water into the North Atlantic Ocean, so the *Peruvian Coast* or *Humboldt's Current*, nearly three thousand geographical miles distant from the shores of America, carries cold water into the Pacific Ocean within the torrid zone. It has been remarked above that Beechey had found the belt of warm water in the eastern part of the Pacific Ocean, and indeed in the Northern Hemisphere, nearly 14½ degrees of the meridian broad. The maximum warmth observed by him, on the northern border of the belt, was 88°. In the western part, between longitude 172° and 177° east, Duperrey found the zone 21 degrees broad, and extending from latitude 18° south to 3° north. Within this space, the temperature of the ocean water was 84°.2 and upwards,[12] it only fell four times under this; once it rose to 86° (in latitude 4° south); and at another time it amounted to 86°.36 by which the maximum of these numerous observations was attained.[13] An equally high maximum was observed at Waigiu (at 4 P.M.), a maximum of 86°.90 (also at 4 P.M.) in latitude 0° 2' north, longitude 140° 47' east. In the Moluccu Sea the maximum was 87°.8, in latitude 7° 43' south, longitude 125° 9' east; and the absolute maximum in the Haven of Doreny, New Guinea, latitude 0° 32' south, longitude 134° 7' east, was observed to amount to 88°.52. The figures indicating the temperature of the ocean, placed on the parallels of the chart, are taken from my sketch of hydrography." There are, besides, a row of figures showing the temperature on the line between Paita in South America (latitude 5° south) and the New Hebrides (latitude 15° south), which we consider valuable as indicating the state of ocean warmth within the torrid zone, in the direction from east to west.

[1] During the gurua the atmosphere loses its transparency, and the sun is observed for months together. "The vapours of the gurua or lama are so much finer the one over through them with the naked eye assume the appearance of the moon's disc. They commence in the morning, and extend over the plains in the form of refreshing fogs, which dissipate some other mid-day, and are followed by heavy dews which are precipitately during the night."—*Edinburgh New Philosophical Journal*, 1826, p. 73.

[2] On the failure of temperature from Callao to the Equator, &c., Berghaus' Länder und Völkerkunde, i., 327.

[3] A. von Humboldt's Asie.

[4] Ibid.

[5] The "ei" in the word Penschinsk is pronounced soft like the French "j."

[6] Krusenstern, Rec. de Mémoires Hydrographiques, t. i., p. 76.

[7] Meyen's Reise um die Erde, ii., p. 82.

[8] Geographischer Almanach, 1827, pp. 322, 353.

[9] Voyage autour du monde. Partie nautique, St Petersburg, 1830, in 4to, p. 100.

[10] Geographischer Almanach auf das Jahr 1827, p. 355.

[11] Flinders' Voyage to Terra Australis, ii., 296.

[12] As by my friend Professor Bronicke, in his excellent work, "Die Festland von Australien," i., p. 130.

[13] General Chart of Terra Australis, from the surveys of Captains Flinders and King, R.N., with additions from Lieutenants Jeffreys and Roe, &c. London, 1820. Compare Krusenstern, Hor. de Memoires, i., p. 52.

[14] If we take the mean of Beechey's observations into account, the general mean will be raised by 0°.06.

[15] Twice, however, it fell to 84 °.2 in latitude 2° 11' south, and 0° 42' north.

[16] This was in latitude 15° 40' south; then the temperature fell on the following day to the mean of 78°.2, and even to 66°.4.

[17] Allgem. Länder und Völkerk unde, i. bd., p. 561.

NOTES

EXPLANATORY OF

THE TIDAL CHARTS OF THE WORLD

AND OF

THE BRITISH SEAS.

BY

J. SCOTT RUSSELL, Esq., M.A., F.R.S., Ed., &c.

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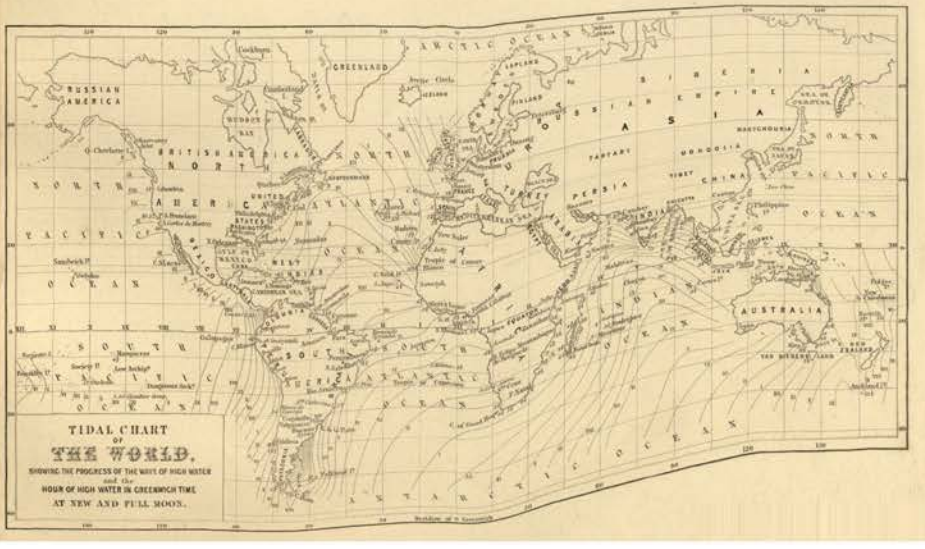
INTRODUCTION.

If the earth presented a uniform globe, with a belt of sea of very great and uniform depth encircling it round the equator, we should have a rise of tide, or high-water, following the sun every day from east to west after mid-day, and another succeeding it after mid-night, when the sun had passed the meridian of our antipodes. This phenomenon Sir Isaac Newton deduced from the laws of the gravitation to each other of the mass of the sun, the mass of the earth, and the mass of the water. In like manner, each transit of the moon over the meridian would bring after it also a tide or high-water; and owing to the smaller distance of the moon, its effect would be greater in raising the water than the effect of the sun, in a proportion nearly six-fold. In this state of matters we might expect four tides a-day. These, however, would so modify each other as to produce only two great tides compounded of the four. When the transit of the sun and moon took place together, their joint effect would raise a tide measured by the sum of the effects; that is, the lunar tide would be increased one-sixth by the solar tide. But, on the other hand, when the transit of the moon was about six hours later or earlier than the sun's, the low-water of the one would diminish the effect of the high-water of the other, and so the lunar tide would be diminished by one-sixth. Thus the mean tidal elevation of high-water would vary in nearly the proportion of 5 to 7. At new and full moon the tides would range higher (forming spring-tides), and at the first and third quarters the tides (forming neap-tides) would range lower. Where there were twenty-one feet of rise of high-water above low-water at springs, there would only be fifteen feet at neaps. Had the earth been formed as we have supposed, with a great equatorial canal, or central belt of ocean, the phenomena might have taken place as we have stated, with great regularity, and we should not have required to form a tidal map or chart, for the crest of high-water would have been nearly (not exactly) a meridional line following the sun and moon at certain very simple intervals. This simple case is, however, very different from the fact, the heights of successive tides and their intervals vary much in the way we have described, but the direction of motion and the epoch or date of high-water are exceedingly various; so different, indeed, that no adequate notion of tidal phenomena can be formed, without some such tidal charts as accompany this paper.

Looking at the Chart of the World, we observe that there is no great equatorial sea extending east and west round the globe, in such a belt as has been imagined. On the contrary, the great continents cross the equator nearly at right angles; the Atlantic running nearly north and south, between Europe, Africa, and the Americas. The chief region of water appears in reality to surround the south pole, and if we recollect how peculiar the nature of the Pacific is, how much it is intercepted with coral reefs and islands, and insular continents, we shall readily perceive how far it is removed from the condition of an equatorial canal of uniform, unimpeded, great depth; presenting, on the contrary, a coral barrier nearly impervious to tidal action.

The source of the tides is therefore to be sought in the great reservoir of ocean round the southern pole. This polar reservoir is agitated on opposite sides by the moon in its alternate lower and upper transits, and by the sun in a less degree. Here the great central agitation seems to commence, and hence on all sides it seems to flow northwards. From the south pole this great agitation flows into the Indian Ocean, and proceeding northward, the great tide-wave strikes with violence on the shores of Hindostan, and finally breaks in the mouths of the Ganges, where it expends its force on the shores in the form of the well-known and terrific bore of the Hoogly. The Atlantic, in like manner, receives from the southern reservoir its great wave of tide, which passes northward with impetuosity, and expends its forces on the shores of Britain and North America, where again it becomes the enormous stream-tide of the Bristol Channel, and the destroying surge of the Bay of Fundi, so well known to all mariners. From the south, in like manner, the Pacific should receive its great tide, were it not barricaded out by innumerable submarine steppes, and its thousand coral reefs, and its myriads of happy islands, to whose calm seas no propagation of this great horizontally-acting wave can gain access. It is by depth and uninterrupted bottom only that a great wave like the tide can force entrance,—it is only the small waves raised by a local tempest, that travel over the surface—an action like the tide, extending uniformly to all depths of ocean, cannot be propagated on a superficial coating alone. The tides are built out of the Pacific by submarine works, and enter it alone and with difficulty by the eastern side of America, where, diffused and rapidly diminishing, the tide extends a certain way through the more open parts of the sea, continually diminishing in intensity. In the North Pacific we have neither the bores of a Hoogly, nor the terrific tides of a Bay of Fundi. It is thus that we shall best understand the tides of these northern seas, in tracing them back to their genesis by the joint actions of the sun and moon on the waters of the Southern Polar Ocean. There we must conceive that the elevation and horizontal motion are first communicated to a vast mass of deep water, which, imparting this impulse to all the surrounding mass, sets in motion the waters of all the southern months of our seas, and propagates to our shores, long after their original force has been impaired, the effects of the derangement of the equilibrium of that central reservoir from which alone our tides are derived. It is this course of transmission of tides from south to north by means of a great tidal wave, which is exhibited in the annexed Chart of the World. The chart exhibited now enables us to follow the history of a tide.



TIDAL CHART
OF THE
BRITISH SEAS.

Showing the Progress of the
WAVE OF HIGH WATER,
THE HOUR OF HIGH WATER IN GREENWICH TIME
AT NEW AND FULL MOON;
and the DEPTH of the SEA.

Constructed under the Direction of
J. SCOTT RUSSELL ESQ.ᴿᴱ F.R.S. ED.
BY A.K. JOHNSTON. F.R.G.S.

THE HOUR OF HIGH WATER IS GIVEN THUS I. II. III. &c
The Rise and Fall of Spring Tides in Yards on the Coast thus 1. 2. 3. &c
The Depth of the Sea is shown by lines of 10. 20. 30. 40. 50. 60. and 70. Fathoms.

Longitude West from Greenwich

Longitude East from Greenwich

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A.K. Johnston.

I.—TIDAL CHART OF THE WORLD

The first idea of a tidal map appears to have been given by Dr. Thomas Young, who exhibits in one of the plates of his Natural Philosophy, by shaded lines, the presence and progress of a great northern tidal wave on the east coast of Britain. The present extended tide map is taken from the map of Sir John W. Lubbock, constructed for his paper on Tides in the *Philosophical Transactions* of 1831; which paper and map have formed the foundation of much that has been done, during the last fifteen years, for the advancement of our knowledge of the phenomena of tides, and for their practical prediction. In that paper he also designates by the term cotidal line, an imaginary line connecting places to which high-water is brought at the same instant by the same tide; and he exhibits on the coast the hours of observed high-water at full and change. On this map cotidal lines were afterwards drawn by the Rev. W. Whewell, now Master of Trinity; and though these are imaginary, and likely to change with our extended knowledge of the form of the bottom of the sea, and the registers of the oscillations of its surface, they may be taken as tolerable representatives of the probable phenomena of the tide. In general a cotidal line will represent the place of the summit of a wave of high-water as it passes successive points along the coast.

It may now be useful to follow the phenomena of the succession of the tides, as indicated by the Chart or the World. Commencing with new or full moon, let us take the spring-tide, or largest tide formed by the coincidence of the actions of sun and moon. Let us conceive that this joint action has taken effect on the waters of the Antarctic Ocean—that the luminaries, in conjunction or opposition, have passed over the mass of waters lying east from Van Diemen's Land, New Zealand, and the South Pole, and have communicated to them motion in the direction of the resultant forces; we shall manifestly have a mass elevated and moving to the north and west, following the luminaries. The motion thus communicated to this mass of water has raised a large mass, or moving ridge of water, which cannot expend its forces acquired, but by pushing before it other masses of water, and raising them, too, in a wave to which all its force is finally imparted. In this way, the wave originally generated travels northward and westward, long after the bodies generating it have ceased to act on the first mass of water. The wave generated during the transit of the sun and moon on Monday morning, and producing high-water on the coast of Van Diemen's Land at twelve, has by noon *nearly* reached the point of the Peninsula of Hindostan, and at one afternoon is at the Cape of Good Hope. Here it enters the Atlantic, and, travelling northwards, brings high-water at the same hours to the western coasts of Africa and the eastern shores of America.

All these seas, save the Antarctic, have the tides delivered into their mouths at the southern aperture. The Antarctic is the cradle of the tides. It is here that the sun and moon have presided over their birth, and it is here also that they are, *so to speak*, abandoned to the guidance of their own congenital tendencies. The luminaries continue to travel round the earth (apparently) from east to west. The tides no longer follow them. The Atlantic, for example, opens up to them a long deep canal, running from north to south; and, after the great tidal elevation has entered the mouth of this Atlantic canal, it moves continuously northwards; for the second twelve hours of its life it travels north from the Cape of Good Hope and Cape Horn, and at the end of the first twenty-four hours of its existence, has brought high-water to Cape Blanco on the west of Africa, and Newfoundland on the American continent. Turning now round to the eastwards, and at right angles to its original direction, this great tidal wave brings high-water, during the morning of the second day, to the western coasts of Ireland and England. Passing round the northern Cape of Scotland, it reaches Aberdeen at noon, bringing high-water also to the opposite coasts of Norway and Denmark. It has now been travelling precisely in the opposite direction to that of its genesis, and in the opposite direction, also, to the relative motion of the sun and moon. But its erratic course is not yet complete. It is now travelling from the northern mouth of the German Ocean southwards. At midnight of the second day it is at the mouth of the Thames, and it is not till the morning of the third day that this wave fills the channels of the Thames, and wafts the merchandize of the world to the quays of the port of London. In the course of this rapid journey, the reader will have noticed how this lines in some parts are crowded together closely on each other, while in others they are wide asunder. This indicates that the tide-wave is travelling with various velocity. Across the Southern Ocean it seems to travel nearly 1000 miles an hour, and through the Atlantic scarcely less; but near some of the shores, as on the coast of India, as on the coast of Cape Horn, as on the east of the American Isthmus, as round the shores of Great Britain, it travels very slowly; so that it takes more time to go from Aberdeen to London, than over the arc of 120°, which reaches between 60° of southern lat. and 60° on the north of the equator. These differences fall to be accounted for: and the high velocities are invariably found to exist where the water is deep, while the low velocities occur in shallow water. We must, therefore, look to the conformation of the shores and bottom of the sea as an important element in the phenomena of the tides.

II.—TIDAL CHART OF THE BRITISH SEAS.

In the large Map of the British Seas it will be observed, that we have indicated the depth of the sea, and the conformation of the bottom, in a manner at once sensible to the eye and precise. The darker shades of the sea indicate greater depths, and the marginal line, bounding any given shade, has marked upon it the exact number of fathoms found all along that line. The eye can thus trace the exact form of the bottom of the sea, as if seen through the waters, on the surface of which the crest of the tide-wave is also visible. It will be useful to study these two phenomena in immediate relation to one another on this map; and also to look at the large map, in connection with the smaller, on the preceding page. The reader will thus understand how the Atlantic wave is first brought to the British Seas, and how next it is distributed through the English and Irish Channels, and across the German Ocean. The explanation of these complex phenomena, as exhibited in the Map of the British Seas, is only to be thoroughly given by considering the tide as a great wave; and, to understand the phenomena of the tide-wave, it is necessary to have some other wave as its type. No wave, presenting any analogy to the tide-wave, or furnishing any explanation of it, was known to philosophers, until the researches of Mr. Scott Russell brought to light what he has called the "Wave of the First Order, or Great Wave of Translation." He found in this wave a phenomenon which, like the tide, extends to the very bottom of the fluid—which, like it, gives to the waters a motion of translation, which is uniform to great depths. He ascertained by experiment, that in shallow water, at least, the tide-wave moves with a velocity equal to that of the wave of the first order, being the same velocity which a heavy body, falling freely by gravity, would acquire in descending through half the depth of fluid. This wave of the first order is, therefore, that phenomenon which presents the closest analogy to the tide-wave, and may be taken to some extent as its type, especially as it approaches our shores or ascends our rivers, and where, no longer obeying the influence of planetary attractions, but subject to the laws of pressure and motion of fluids, it is now diverted one way, and now another, according to the forms of the shore, and the undulations of the bottom of the sea. Dr. Whewell, in his paper of 1833, made use of a hypothesis of this kind for the construction of his *Cotidal Lines*, and has since re-constructed them, especially in the German Sea, on various modifications of it. In the Map of the British Seas, we have given to the ridge of the tide-wave that form which would most nearly coincide with what has been observed of the motion of the wave of the first order—the only form by which at present we are able to guide our researches. The following is a table showing the velocity of the tide wave, considered as a wave of the first order, in different depths of the sea:—

| | | |

THE RIVER SYSTEMS OF EUROPE AND ASIA,

SHOWING

THE BOUNDARIES AND COMPARATIVE EXTENT OF THE RIVER BASINS, AND THE SEAS TO WHICH THEY CONTRIBUTE THEIR WATERS.

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INTRODUCTION.

GREAT rivers are the bonds of union which unite the people of different tribes or countries; and if they terminate in the ocean, they form an important link in the chain of the physical phenomena which tend to the improvement of the social life of man. In this respect the countries of Europe as well as those of Southern and Eastern Asia are highly favoured, whilst Northern Asia has no such advantages; for although its river systems are so extensive as to rank amongst the greatest in the world, yet the climatic element interposes to destroy their usefulness. The mouths of the Oby, the Yenesei, and the Lena, are almost constantly covered with ice. Hence Northern Asia can take no part in the commerce of the world, from which also Central Asia, or the district of the continental streams, is excluded.

Rivers are currents of water flowing through the land in open channels; they are formed from the accumulated waters of brooks and rivulets, which originate generally in springs; and these latter have their origin in the precipitation which falls from the clouds in the form of rain and snow, and this precipitation is the condensed vapour which is raised from the surface of the earth by the action of heat. There is thus a continual interchange between the earth and its atmospheric covering; for what the earth contributes to the atmosphere in the form of vapour is returned as rain or snow.

EXPLANATION OF THE MAP.

In order to present a connected view of the river systems of the northern part of the Old World, we have here, as in the map of the Mountain Chains, considered Europe as a peninsular prolongation of Asia. We have thus been enabled to indicate the comparative size of the areas of river basins, and the slope of the countries toward the seas into which the rivers discharge themselves. This form of construction was also necessary for the representation of the great central plateau, which forms the basin of the continental streams.

I. OCEANIC RIVERS.

The oceanic streams of Europe and Asia contribute their waters to four different seas, and these are distinguished by different colours on the map. From which it appears that the rivers of Europe empty themselves chiefly into the Atlantic Ocean and its branches; those of Southern Asia flow exclusively into the Indian Ocean; those of Eastern Asia, into the Pacific Ocean; and those of Northern Asia, into the Arctic Sea, to which also Northern Europe contributes its waters.

Hence it appears, that the principal rivers of Europe flow generally in a north-west and south-east direction, indicating the two great declivities of this quarter of the globe occasioned by the form of its mountain regions. The great northern declivity of Asia extends northwards from the basin of the continental streams to the Arctic Ocean, and in a direction from east to west, between the Ural Mountains and the Pacific Ocean; the southern declivity carries all the waters south of the Himalayan Mountains and the Caucasus to the Indian Ocean and the Persian Gulf; the eastern declivity is indicated by the rivers which flow to the Pacific Ocean and the China Sea; and the western by those flowing from the west of the Bolor Mountains.

II. CONTINENTAL RIVERS.

These occupy the centre of the Map, and their Basins are SHADED *with Pecise.*

The basin of the continental streams, as we have termed it, commencing near the Gulf of Finland and the Black Sea, extends eastward through the whole of Inner Asia, nearly to the Yellow Sea, comprising an extent of more than three millions of imperial square miles. This district, besides the numerous rivulets of the steppes, and many extensive lakes, contains the Volga, the principal river of Europe, and the Caspian Sea, the greatest lake in the world. There is thus a remarkable distinction between the oceanic and the continental streams; the rivers of Inner Asia, and a great part of Eastern Europe, do not immediately reach the sea; many extensive streams are confined exclusively to the continent, sometimes discharging themselves into lakes, and at others, though more rarely, they are lost in the sands of their own channels.

III. RIVER BASINS.

The river basins are distinguished by narrow lines of the same colour as the ocean districts. These lines represent the watershed, and consequently indicate the highest land of a river basin, the lowest part of which is occupied by the main stream. The figures placed above the name of the river show the extent of the basin in square miles; those below the name, its extent as compared with the district of the Pregel, which is shaded by dark lines on the map. This district, which is assumed as unity, is of nearly equal extent with that of the Severn in England, which is similarly shaded on the map.

HYDROLOGICAL EXPLANATIONS REGARDING RIVERS.

I. BASINS.

The entire sources, brooks, and rivulets, whose waters contribute to the formation of a river, from its source to its termination, or the surface of the country which is drained by it, form its district or basin. This definition applies to every river, whether principal or affluent; thus river basins vary in size from the district of the smallest brook to that of a main stream or principal river. The size of a river basin depends, in general, on the extent of the continent or quarter of the earth to which it belongs.

Europe, which, next to Australia, is the smallest division of the earth, possesses the smallest river districts; America and Asia the largest.

II. WATERSHED AND PORTAGE.

The place whence flowing waters begin to descend in opposite directions is called the *watershed*. This marks the limit of the river basin, and forms a line either along the declivities of mountains or in plains. In the latter case the watershed is often so flat that barges can be easily conveyed over the country which separates the different river basins; and those places which are most suitable for this purpose, or for being united by means of canals, are called *portages*.

III. BIFURCATION.

Mountains and watersheds are not, as has been erroneously assumed, the same. Mountains have often, in proportion to their size and extent, only a very unimportant influence on the form and direction of watersheds; and there are cases, for example, in North America, where opposite river basins have their origin in lakes. And, contrary to the prevailing opinion, it is now found that opposite river basins are sometimes connected by natural water courses, in consequence of such a depression of the surface of a country as permits the water of a river, after being diverted from its proper channel, to join another river with which it is otherwise unconnected. The most remarkable phenomenon of this kind, which is called the *bifurcation* of a river, occurs in the basin of the Orinoco.[1]

IV. SIZE AND LENGTH OF RIVERS.

The importance of a river is estimated by the length of its course; but in this the direct distance from the source to the mouth must be distinguished from that which includes the windings which it describes. From a comparison of both values is deduced the length of the river course, which is the more important the shorter the direct distance is from the source to the mouth, and the more numerous its windings. This is more especially the case if the river be navigable through a great part of its course.

The quantity of water in a river increases, generally, with the size of its district or basin, and the number of affluents which contribute to its formation; hence, in general, rivers have the greatest amount of water at their mouths, or towards the end of their course. The amount of water in a river varies with the seasons, and depends in some cases on the extent of the atmospheric deposition, in others on the melting of snow; thence on the state of heat, and in all cases on meteorological and climatic conditions.

[1] See River Basins of South America, No. 6 of this Division.

Rivers are not extensive in proportion to the elevation of their sources, as was formerly supposed; for the Volga, the largest of European rivers, rises at a height of only 1,100 feet above the level of the sea. But the greater number of large rivers have their origin in high mountains, or elevated table-lands.

V. RIVER COURSES.

Three degrees of development are observed during the progress of a river from its source to its termination, viz., the upper, the middle, and the lower course; and these may be, according to circumstances, more or less fully recognised.

In their *upper course*, rivers flow in channels inclined to the horizon; and in descending the declivities of mountains, the bed of the current forms a narrow gorge confined by high and steep rocky sides, between which the water flows, or rather rushes, from the steep declivities in foaming waterfalls and cascades. Such is the character of the upper course of streams which have their origin in high mountains, and before changing this they usually form waterfalls, which mark the transition to the *middle course*. In this, the middle course, the declivity of the river bed is less rapid, the stream flows over a comparatively level or hilly country, the channel is broader, and instead of the sharp angular lines of the upper course, the river describes rounded bends, and serpentine meanderings, and its low banks are sometimes broken through by the force of the mass of water, which finds for itself a new channel.

VI. DELTAS.

If the middle course of a river be enclosed by a mountain chain, it must force its way through, in order to reach the lower course. In this transition, the appearances of the upper course are repeated, although on a smaller scale. The bed of the stream contracts, and produces the phenomenon of rapids. Here the *lower course* begins: the river now flows generally through a plain, the current is very slow, the declivity of its bed being almost imperceptible; and towards its termination it is characterized by the efforts of the water to divide and ramify, imparting to the regions of its mouth the form which, from its resemblance to the Greek letter Δ, is called the *delta* land of the river. This is caused by the solid matter brought by the river being deposited, and filling up a former bay of the sea, or by a natural obstacle, which divides the stream into two or more branches. But this form of the mouth is not general; some streams discharge themselves into a bay, which, in this case, is called a negative delta; or they find an outlet in a lake-like extension or lagoon, which, separated from the sea by downs, has a very narrow channel, at the mouth of which is usually a bar or shoal. Others, again, discharge themselves at once into the sea, when their currents may be traced to a great distance from the shore. Deltas are *fluviatile* when formed at the entrance of one river into another; *lacustrine*, when at the embouchure of a river into a lake; and *maritime* when the river falls into the sea. Within the deltic branches there are frequently many other diverging and anastomosing branches, which, for distinction's sake, may be called ana-deltic, and which cut up the delta into a greater or less number of deltic islands.[1]

VII. VELOCITY OF RIVERS.

The velocity of a river depends on the form of the channel, its inclination, and the volume of water contained in it. If the water met with no resistance from its banks, the velocity of a river would depend upon the accelerating force of gravity, which would soon become so great as to render it the instrument of devastation and ruin over its whole course. The Thames, which has a descent of only one

[1] See valuable "Hints on the Subject of Geographical Arrangement and Nomenclature," Journal of the Royal Geographical Society, vol. iv., p. 72.

THE RIVER SYSTEMS OF ASIA & EUROPE,

Showing the Boundaries and comparative extent of

THE RIVER BASINS

AND THE SEAS TO WHICH THEY CONTRIBUTE THEIR WATERS.

Extended from the Original Designs of

PROFESSOR BERGHAUS, BERLIN,

BY A.K. JOHNSTON, F.R.G.S.

NOTE

In this Map the area of the River basins is given in Geographical Sq. Miles, and each is compared with that of the Projet (1) which is reckoned = 1. The figures placed over the names of the basins show the extent of surface in Square Miles, and those below, the extent as compared with the Projet: for instance the district of the Obi is 39,040 Sq. Miles in extent, and 6 times greater than that of the Projet. The greater part of these figures can only be considered as an approximation to the truth.

(1) Lat. 52° N. Long. 20° E. the Basin of the Projet corresponds in extent nearly, with that of the Severn, which is similarly shaded on the Map. (2) Lat. 52° 22' N. Long 14° 45' E.

Explanation of the Colours

- District of the Atlantic Ocean
- " Indian "
- " Pacific "
- " Arctic "
- Basin of the Continental Streams

The River Basins are separated by narrow lines of the same colour as that which defines the several districts.

COMPARATIVE VIEW OF THE FALL OF THE RIVERS

VOLGA, GANGES, DANUBE, ELBE, RHINE, RHONE & CLYDE

WITH THE POSITIONS

of some of the most remarkable LAKES above & below the Level of the Sea.

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A.K. Johnston

hundred feet, would then flow at the rate of fifty-four miles an hour; and the Rhone, which receives the great body of its waters at an elevation of nine hundred feet, would acquire at its mouth a velocity of one hundred and sixty-four miles an hour. The molecules of water in contact with the sides and bottom of the channel, being retarded by friction, move more slowly than those at the surface and centre; and hence, the greatest velocity of a river, flowing in an open channel, is in the middle of the current; and in consequence of the pressure of the upper stratum of water tending to give greater velocity to that which is under it, this maximum is found at a little depth below the surface. The greatest velocity is to the mean velocity nearly in the proportion of five to four. Thus, if the greatest velocity is determined by experiment, the mean may be assumed at four-fifths of the amount nearly.

VIII. DEVELOPMENT OF RIVERS.

The length of a river, from its source to its mouth, including all its windings and turnings, is called its development. If we compare this development with the direct distance between the source and the mouth, we ascertain the amount of the windings, and thus arrive at a scale for determining the influence which the river exercises on its district. In order to this we have to consider not only the length of the principal channel, but also the surface extent of all its tributary channels. These, in reference to the horizontal extent of the rivers of Europe and Asia, are given in a table below, in which all the data are quoted which can be expressed in figures.

HYDROGRAPHIC TABLE OF EUROPE AND ASIA.

*** From the present defective state of hydrographic knowledge, this table must be considered as giving only approximate results.

Names of Rivers.	Extent of River Basins in Geographical square Miles.	Direct Distance of Rivers from Source to Mouth, in Geographical Miles.	Extent of Development of Streams, in Geographical Miles.	Extent of Windings of Streams, in Geographical Miles.	Proportion of Windings to Direct Distance of Rivers.
		Geographical Miles 60 to a Degree.			
Atlantic System.					
Neva,	67,260?	315?	440?	125	0.4
Rhine (Rhein),	65,280	360	600	240	0.6
Vistula,	56,640	280	520	240	0.8
Elbe,	41,760	344	684	340	1.0
Oder,	39,040	280	480	200	0.7
Leitra,	33,240	320	520	200	0.6
Duna or Dvina,	33,440	280	560	280	1.0
Niemen,	32,180	240	460	220	0.9
Dnieper or Dnepr,	29,250	260	440	180	0.7
Garonne,	24,450	200	320	120	0.6
Seine,	22,628	220	340	120	0.5
Tagus,	21,760	260	480	220	0.8
Guadiana,	19,260	240	420	180	0.7
Guadalquivir,	15,040	180	260	80	0.4
Weser,	13,120	200	280	80	0.4
Minho,	11,840	188	192	50	0.4
Pregel,	5,920	60	100	40	0.7
Mediterranean System.					
Nile,	526,200?	1,320?	2,240?	920	0.7
Po,	29,920	272	392	120	0.5
Rhone,	28,160	248	580	332	1.7
Ebro,	25,100	268	420	152	0.5
Euxine System.					
Danube (Donau),	254,080	880	1,496	616	0.7
Dniepet,	189,680	548	1,080	532	1.0
Don,	168,420	408	960	552	1.3
Dniester,	23,040	360	440	80	0.2
Arctic System.					
Obi,	524,860	1,276	2,320	1,044	0.8
Yenesei,	784,630	1,228	2,800	1,572	1.2
Lena,	332,400	1,280	2,400	1,004	0.7
Kolyma,	107,200	440	800	208	0.4
Dwina,	106,400	380	864	484	1.3
Indigirka,	86,400?	260?	908?	248	0.6
Olenek,	76,800	600	1,000	400	0.7
Anadir,	63,360?	. .	. .	. .	. .
Petchora,	48,960	360	600	240	0.7
Mezen,	30,350?	. .	. .	. .	. .
Continental System.					
Volga	397,460	900	2,400	1,440	2.4
Oural / Caspian Sea,	83,200	350?	. .	. .	. .
Kour	64,640	300	540	220	1.0
Sir or Sihon / Aral Sea,	257,920?	600	1,208?	448?	0.7
Amoo or Gihon /	193,600	816	1,400	584	0.7
District of Lob Lake,	177,120	622	1,088	388	0.5
Pacific System.					
Amoor,	352,880	1,200	2,380	1,180	0.9
Yang-tse-Kiang,	547,800	1,150	2,350	1,212	0.8
Hoang-Ho,	537,400	1,150	2,350	1,160	1.0
Tche-Kiang,	99,200	480	960	488	1.0
System of Indian Ocean.					
Ganges (including the Basin of the Brahmahoutra),	432,480	824	1,680	856	1.0
Indus,	312,000?	900?	1,960?	864	0.8
Mesam,	216,000?	620?	940?	320	0.5
Euphrates,	195,680	600	1,492	892	1.5
Gedavery,	92,800	540	748	360	0.8
Kistna,	81,600	440	688	228	0.5
Irrawady,	331,200?	1,100	2,200	1,028	0.5

Remarks.—From this table many instructive comparisons may be made.

For example, the direct length of the Vistula, from its source to its mouth, is 280 miles, and the development of the stream requires a course of 520 miles. The meanderings thus occupy 240 miles, or nearly nine-tenths of the direct distance, thus indicating the great amount of irrigation which this river communicates to its district. Again, the direct distance of the Rhine, from its source to its mouth, is shown to be 360 miles, or 80 miles more than the Vistula; the development of its course is 600 miles, also 80 miles greater than the Vistula; but the proportion of its windings amounts to only two-thirds of its direct course; the windings are therefore less than those of the Vistula, notwithstanding that the district of the former is much greater than that of the latter river. These comparisons may be extended to all the other systems.

Reckoning the whole running waters of Europe = 1.00, we find the proportion for those rivers which discharge themselves into the different seas to be as follows:—

Black Sea	0.27 parts.
Caspian Sea	0.16 „
Mediterranean	0.14 „
Atlantic Ocean, about	0.13 „
Baltic Sea	0.13 „
German Ocean	0.11 „
Arctic Sea, about	0.06 „

This shows that the greatest amount of water is carried to the Black Sea, since it engulfs nearly the third part of all the running water of Europe. Again, nearly one-half of the whole running water of Europe falls into the Black and the Caspian Seas; which is the more remarkable as the one is an inland sea, situated in the interior of the continent, and the other a completely enclosed inland lake.

Comparing the river systems of Europe among themselves, we find, for the six largest, the following results:—Assuming the whole rivers of Europe = 1.00, the

Volga discharges thereof	0.14 parts.
Danube	0.12 „
Dnieper	0.06 „
Don	0.05 „
Rhine	0.03 „
Dwina	0.02 „

From this it appears that the Volga alone carries off as much water as the Mediterranean receives from Europe; that the waters of the Danube are almost as considerable as those of all the rivers which empty themselves into the Baltic Sea, &c.

COMPARATIVE VIEW OF THE FALL OF SOME OF THE PRINCIPAL RIVERS, AND POSITIONS OF THE MOST REMARKABLE LAKES, WITH REFERENCE TO THE MEAN LEVEL OF THE SEA.

On the under part of the plate we have given sections of the elevations of the Rivers Volga, Ganges, Danube, Elbe, Rhine, Rhone, and Clyde, at different parts of their course, from their source to their termination. These profiles are coloured to correspond with the ocean districts on the map—the elevations are measured from the vertical scale of English feet on the left side of the diagram, and the lengths from the horizontal scale of miles at the foot.

The Volga, the longest and the most level of the rivers here represented, has its origin in a small lake on the slopes of the plateau of Valdai, at an elevation of about 850 feet above the level of the ocean,[1] whence it flows in a gently inclined bed to its termination in the Caspian Sea, 83 feet below the level of the Euxine. Its entire fall, over a course of more than 2,400 miles, therefore, amounts to only 933 feet.

The Ganges, the source of which, in striking contrast with the Volga, is placed at the highest point of the diagram, issues from the southern slopes of the Himalaya Mountains, at an elevation (reckoning from the point where the Bhagirathi source springs from under the glacier) of 13,872 feet. It falls rapidly to Hurdwar, where it enters the great plain of Hindostan, and thence flows with a smooth current to the ocean, which it enters by numerous mouths in the Bay of Bengal.

The Danube.—This celebrated river originates in the Brege, a mountain torrent on the eastern declivity of the Schwarzwald, at an elevation of 2,850 feet above the level of the sea. This stream is afterwards joined by the Beigach, and by the waters of a spring from the castle garden at Donaueschingen, in the Duchy of Baden, when the united stream takes the name of Donau or Danube. From this point it runs through an alpine country to Ulm, thence to Passau it traverses the plain of Bavaria. From Passau to Vienna it runs through a second hilly region, and the remainder of its course is generally through a flat country, except on approaching the rocky defile of the "Iron Gate," till it reaches its destination in the Black Sea. The section of the Danube on the boundaries of Germany and Hungary, shows a remarkable coincidence with that of the Ganges at Allahabad, in the lowlands of Hindostan.

The Elbe rises in the western slopes of the Schnee-Koppe, in the Riesengebirge and the neighbouring mountains, from upwards of 30 springs, the southernmost of which, the *Elb-brunnen*, is situated at the elevation of 4,500 feet. The navigation of this important river is much impeded by the lowness of its bed, the greater part of its course, as shown on the diagram, being only from 150 to 300 feet above the level of the sea; and its estuary, at Cuxhaven, is encumbered with sand-banks.

The Rhine originates in two streams of the same name—the *Hinter* and *Vorder Rhein*. The first springs from the Rheinwald Glacier between Portahorn and S. Bernardin, and after a north-east course of about 35 miles it joins the Vorder Rhein at Reichenau. The Vorder Rhein springs, under the name of the Rhein de Tomo, on the north side of the S. Gothard, at a height of 7,650 feet; it has a rapid declivity to the Boden See (Lake of Constance), the elevation of which is only 1,250 feet, and after forming the celebrated falls of Laufen, the division of the Upper Rhine terminates at Basel, with an elevation of upwards of 800 feet. The lower course of this important river is navigable from Basel to the German Ocean, and its delta is larger than that of any other European river.

The Rhone has its source in the Rhone Glacier on the west side of the S. Gothard, between the Furka, Galenastock and Grimsel, at an elevation of 5,500 feet above the level of the sea. Rising in the same mountainous country, although flowing in an opposite direction, the upper part of its course bears a striking resemblance to that of the Rhine, and the lakes of Geneva and Constance, which are formed by it, are nearly at the same distance from the sources of the Rhone as the Rhine, differ only by about 200 feet in elevation. But the under course of the Rhone has a much greater declivity than that of the Rhine; for while at St. Genis, the former is still 640 feet above the sea, the latter, at a corresponding distance from its mouth, namely, at Mannheim is less than 360 feet. The Rhone has consequently a much more rapid course than the Rhine; it enters the Mediterranean by two principal mouths.

The Clyde, the only important river on the western coast of Scotland, rises in the range of mountains which separate the southern extremity of Lanarkshire from the counties of Dumfries and Peebles, at an elevation of 1,400 feet. Near Lanark, it is precipitated over a series of highly picturesque falls, after which it flows over a gently inclined bed to the vicinity of Glasgow, whence it has been made navigable to its embouchure in the Firth of Clyde.

POSITIONS OF THE MOST REMARKABLE LAKES ABOVE AND BELOW THE LEVEL OF THE SEA.

These are placed simply in the order of their importance as regards elevation, on the right side of the diagram; and next to those in the case of rivers, from the scale of *level* feet on the left. The highest point on the scale represents Lake Sir-i-Kol, and the lowest the Dead Sea; between these two points there is a space of nearly 17,000 feet, a portion of which is occupied by the relative positions of some of the best known lakes in different parts of the globe. Lake Sir-i-Kol, whence issues the river Oxus, is situated in the district of Pamir, at an elevation of 15,600 feet above the sea, as ascertained by Lieut. Wood, in his journey to the source of the River Oxus in 1838.

The Lake of Titicaca, in the table-land of Bolivia, is, according to Pentland, 12,795 feet above the level of the sea. The Trith Lake in Switzerland has an elevation of 7,200 feet, and even the small lake on Ben Nevis is upwards of 3,800 feet, while Lake Superior is only 672 feet above the level of the sea. Descending below the level of the ocean, we find the Caspian Sea (the altitude of which has at last been so satisfactorily ascertained) depressed 83.6 feet below the level of the Black Sea.[2] Still lower in the scale is the Lake of Tiberias, 328·98 feet, and lowest of all the Dead Sea, 1312·2 feet below the level of the Mediterranean. The exceedingly interesting fact of the amount of depression of this sea, which the barometrical measurements of Moore, Schubert, Russegger, and others left undecided, was finally ascertained by the geodetical operations of Lieutenant Symonds in 1841.

[1] Müller gives an elevation of upwards of 900 feet, but this must be a mistake, since the mean height of the Valdai Hills is *only* 561 feet, and the lake is situated on the plateau considerably to the south of the range.—*See Humboldt's Asie Centrale.—Map* to Vol. 3.

[2] See Mr. W. D. Cooley's excellent translation of Parrot's Journey to Ararat, appendix.

THE RIVER SYSTEMS OF AMERICA,

SHOWING

THE BOUNDARIES AND COMPARATIVE EXTENT OF THE RIVER BASINS, AND THE SEAS AND LAKES TO WHICH THEY CONTRIBUTE THEIR WATERS.

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INTRODUCTORY NOTE.

In the notes to the preceding map it has been shown that the largest rivers in the Old World occur in Asia—the greatest and most connected mass of land on the globe; and in the present it will be found, that although the northern and southern portions of the New World are each much smaller in superficial area, they yet possess streams which, for the extent of their development, and the size of their basins, greatly surpass those of Asia.

America, indeed, has the greatest rivers on the surface of the globe; these and her lakes constitute her grandest natural features; and in them she possesses a medium of commercial intercourse unrivalled in the world.

An inspection of the maps of the Mountain Chains of North and South America will most readily explain the formation of the river basins, since the direction of river-courses depends on the orographical configuration of a country—the forms of great plains being determined by the slopes of the mountains, and those of secondary valleys by the more gentle declivities of the soil. Thus, while the greatest river of North America—the Missouri-Mississippi—confined on the west by the Rocky Mountains, and on the east by the Alleghanies—flows south to the Gulf of Mexico, the Marañon, rising on the western border of the southern continent, flows in an easterly direction to the Atlantic Ocean. From the peculiar formation of its mountain chains, all the great rivers of America flow to the east, north, or south; and notwithstanding the immense development of its western coasts, no river of importance, except the Columbia, reaches the Pacific Ocean. Extending our views of the dependence of the hydrographical on the orographical peculiarities of countries, we shall find that by far the greater number of important rivers on the globe reach the ocean in an easterly direction; those which flow to the south and north being next in importance, while those having a westerly course are few in number, and comparatively insignificant in extent.

In the following brief notice of the principal basins into which this "land of waters" is divided, it will be observed that America presents many striking hydrological peculiarities, and furnishes ample opportunities for comparison with the corresponding phenomena of the Old World, to which our limited space will only admit of a passing allusion.

NORTH AMERICA.

The rivers of North America contribute their waters to the Atlantic, the Pacific, and the Arctic Oceans. The low watershed dividing the rivers which flow in a northern and north-eastern from those which flow in a southern direction, crosses the continent between latitude 40° and 50° north.[1] To the northward of this line is the region of lakes, which, in an almost countless number of lakes and marshes, presents the greatest mass of fresh water on the surface of the globe. In consequence of the very slight elevation of the soil in these regions, natural communications are often established during the rainy season, between rivers which flow in opposite directions, and the mouths of which are situated at a great distance from each other, as in the case of the junction of the branches of the upper Mississippi with the southern tributaries of Lake Winnipeg. And one of the principal tributaries of the Mississippi, the Illinois, is so nearly on a level with Lake Michigan, and so little separated from it by inequality of surface, that at the time of flood it is possible to sail from the one to the other. The abundance of water, and the lowness of the watershed, greatly favour the establishment of *portages*, without which it would be impossible to traverse this desolate region.

Basin of the Great Lakes, and of the River St. Lawrence.—The series of lakes sometimes called the Canadian Sea, which lie to the south of Hudson Bay, forms a connected chain, extending in a direction from west to east, united by short river courses, or lake straits. The westernmost of these, *Lake Superior*, the largest fresh-water lake in the world, discharges its waters through the river or Strait of St. Mary, 50 miles long, into *Lake Huron*, into which also *Lake Michigan* pours its surplus waters, through the Strait of Mackinac, 40 miles in length. The waters of Lake Huron next pass by the River and Lake St. Clair and the Detroit River, 25 miles long, into *Lake Erie*. This, the fourth link in the great chain, sends its surplus waters northwards, by the Niagara River, into *Lake Ontario*, forming, in its course of 33½ miles, the celebrated Falls of Niagara.

The River St. Lawrence rises under the name of the St. Louis, in latitude 47° 45′ north, longitude 93° west, and falls into the south-western extremity of Lake Superior. Quitting Lake Ontario at Kingston, it takes the name of the Iroquois, and flows in a north-easterly direction, forming, in its course, the wide expanses called Lake St. Francis, Lake St. Louis, and St. Peter's Lake. It first takes the name of the St. Lawrence after passing Montreal. Below Quebec it forms a broad estuary, and enters the Gulf of St. Lawrence at Gaspé Point, by a mouth more than 100 miles in width. The basin of the St. Lawrence is watered by many considerable streams, several of which fall into the different lakes; but no river of any importance flows into it from the south. As divided by the coloured lines on the map, this vast basin is estimated to contain 297,000 square miles, of which, according to the following table, 94,000 are covered with the water of the lakes alone:—

TABLE OF THE EXTENT, ELEVATION, AND DEPTH OF THE GREAT LAKES.[2]

	Mean length in Miles.	Mean breadth in Miles.	Mean depth in Feet.	Elevation above the level of the Sea in Feet.	Area in square Miles.
Lake Superior,	400	80	900	596	22,000
Green Bay,	100	20	500	578	2,000
Lake Michigan,	320	70	1,000	578	22,400
Lake Huron,	240	80	1,000	578	20,000
Lake St. Clair,	20	18	20	570	300
Lake Erie,	240	40	84	565	6,000
Lake Ontario,	180	35	500	232	6,300
River St. Lawrence,	.	.	20	.	940
			Aggregate,	. . . .	94,000

According to this estimate, the lakes occupy a surface larger than that of Great Britain, and contain 11,300 cubic miles of water, or more than half of all the fresh water on the globe. They are situated on four terraces differing in elevation, of which Lake Superior occupies the highest, and Lake Ontario the lowest point. The bed of those lakes forms the most remarkable depression in this part of the globe; for the bottom of Lake Ontario, the surface of which is only 232 feet above the level of the Atlantic, and its mean depth 500 feet, is 268 feet below that level; whilst Lake Superior, with a mean depth of 900 feet, is elevated 596 feet at the surface, which gives to its bed a depression of upwards of 900 feet below the level of the ocean.

Basin of the Missouri-Mississippi.—The Mississippi is the largest river of North America, and one of the greatest in the world. With its numerous tributaries, it occupies the whole of the southern portion of the great central basin which M. Balbi calls the plain of the *Missisippi-Mackenzie*. The course of the Mississippi forms such a regular succession of curves, that, in navigating it, the Indians were accustomed to calculate their progress by the number of bends they had passed. Its source, as ascertained by Mr Schoolcraft, in 1832, is Itasca Lake (*Lac la Biche* of the French), situated to the south-west of Cass Lake, at an estimated elevation of 1,500 feet above the Atlantic Ocean. About 700 miles from its source it is precipitated over the *Falls of St. Anthony*, forming a beautiful cataract 17 feet in descent. The principal branch of the Mississippi, which it greatly surpasses in the length of its course, and the volume of its waters, although it loses its name in the inferior stream, is the *Missouri*, which drains the north-western angle of the basin. It rises in two branches on the eastern declivity of the Rocky Mountains, between 42° and 43° north latitude, within a mile or two of the sources of the Columbia, and, augmented by many great affluents, it joins the Mississippi after an estimated course of upwards of 3,000 miles. The middle course of the Mississippi terminates at the mouth of the Missouri; from this point the course of the united stream is gentle, and little interrupted by islands. After receiving the waters of the Red River, it separates into two principal branches, the westernmost of which is the Atchafalaya, and the eastern, the true Mississippi. (See map of the Delta.) These branches are subdivided by many smaller ones, which, with the former, constitute the delta of this great river, so remarkable for the number of its lakes and marshes. The Mississippi is navigable to the Falls of St. Anthony, about 2,240 miles from the sea. It falls into the Gulf of Mexico by several mouths, after a course of 3,160 miles, measured along the course of the stream; but reckoning the Missouri as the principal branch, the whole course may be calculated at upwards of 4,400 miles. The Missouri is navigable from the great falls in latitude 47° to the sea, a distance of 4,000 miles; and it has been ascended by steam-boats 2,200 miles from the Mississippi. Among the many streams which fall into the Gulf of Mexico, on the east and west of the basin of the Mississippi, the Rio Colorado and the Rio del Norte are the chief; the latter rises south of the Sierra Verde, but little is yet known of its upper course.

Basins of the Saskatchewan, Albany, Churchill, and Mackenzie.—The rivers whose basins are here enumerated, with some others less known on the east of Hudson Bay, occupy the northern declivity of the great central plain already noticed, and contribute their waters to the Arctic Ocean and Hudson Bay (or more properly, Hudson Sea). The whole region is covered with lakes, among which are the Winnipeg, one of the greatest lakes of America, Lakes Winnipegous, Manitoba, Deer, Wollaston, Athabasca, Great Slave and Great Bear Lakes, all of which are of vast extent, besides a multitude of inferior lakes, and lake-like expansions of the rivers.

The *Saskatchewan River* rises with two branches in the Chippewyan or Rocky Mountains; these unite at about 450 miles from their sources, and at a distance of 650 miles the united stream falls into Lake Winnipeg, whence it issues, under the name of the Nelson River. This is the largest river which flows into Hudson Sea.

The *Churchill* or *Missisinippi River* is said to rise in Meythe Lake, but its sources are not sufficiently ascertained; it appears to communicate with Lake Wollaston by the Deer Lake, and thence enters the basin of the Mackenzie River.

The *Albany* has its source in Lake St. Joseph, about 300 miles west from its mouth.

The *Severn* falls into Hudson Sea in latitude 56° north, but its origin is uncertain; some maps make its source in Lake Winnipeg.

The *Mackenzie* is the largest river which contributes its waters to the Arctic Ocean in the western hemisphere. It is formed by the union of several small streams which rise on the eastern slopes of the Rocky Mountains. The most important of these are the Athabasca and the Peace Rivers; after passing through Athabasca Lake, these unite to form the Slave River, which, on leaving Great Slave Lake, is called the Mackenzie.

The *Coppermine River* traverses the country of the Copper Indians, and passing through several lakes, and over numerous cataracts, it enters the western part of Coronation Gulf, one of the most remarkable inlets of the Arctic Ocean.

Atlantic Coast Rivers.—Most of the streams which flow to the Atlantic Ocean rise in the range of the Alleghany Mountains, which divides the coast region from the basin of the Mississippi. Consequently, none of them have a very lengthened course; but, as many of them expand into magnificent bays and harbours, they are of the utmost importance to the commerce and manufactures of the country. The largest of the northern rivers is the Hudson, which has its source in the western valley, on a level with the great lakes; it is navigable to Albany. The Delaware and Susquehanna are important rivers, terminating in spacious bays. The Potomac, which falls into Chesapeake Bay, passes Washington, the capital of the United States, to which the largest ships can ascend; and the James has a navigable channel of 320 miles.

Basins of the Columbia and Western Colorado.—The only important river of North America which contributes its waters to the Pacific Ocean is the *Columbia* or *Oregon*, which rises in the most rugged steeps of the Rocky Mountains. It forms in its course many rapids and cataracts, presenting great obstacles to navigation; yet vessels of small burden can ascend to Point Vancouver, a distance of about 100 miles, to which point the tide is perceptible.

The *Fraser* has but a limited course; rising in the Rocky Mountains, near the sources of the Columbia; it has a rapid current, and is quite impassable for boats, on account of its numerous cataracts.

The *Colorado* (western) descends from the Sierra Verde, and after receiving the Jaquesila and the Gila, it mixes its waters with those of the Gulf of California. This river, which is said to be navigable for boats, traverses a country almost unknown.

Basins of the Isthmus of Mexico and Central America.—The countries of New Spain, from their elevated position, possess no navigable rivers of any importance. The narrow form of the continent prevents the accumulation of great masses of water, and the rapid slope of the Cordilleras imparts to many of them the character of torrents, which form in their course innumerable falls.

The largest river in the isthmus is the Rio Grande Santiago, called, in its upper course, the Rio de Lerma. It rises in the table-land of Toluca, and passing through Lake Chapala, it forms numerous falls, and reaches the ocean after a course of about 400 miles. In the table-land of Mexico, between latitude 22° and 26° north, there is a basin of *continental streams*, which, rising from springs on the eastern side of the Sierra Madre, and fed by the periodical rains, flow northwards, and terminate in lakes which part with their surplus waters by evaporation. Among these, the Rio Grande, which is lost in Lake Parras, has a course of upwards of 200 miles; and north of latitude 30° north, the Lakes Guzman and Patas receive similar streams of more than 100 miles in length. These streams are used for the irrigation of the country, which, but for them, would be utterly unproductive, since rains fall only in the month of September, and even then they are very uncertain.

In *Central America*, all the rivers flow either to the Pacific Ocean or the Gulf of Mexico. The courses of many of these are still very imperfectly known. The Motagua, which rises in the mountains near Guatemala, and flows into the Gulf of Honduras, offers the longest line of navigation. The San Juan, flowing from Lake Nicaragua to the Caribbean Sea, has acquired importance from the project of uniting the Atlantic and Pacific Oceans by means of a canal, of which it was to form the eastern bed.

SOUTH AMERICA.

On entering the continent of South America, two small rivers, otherwise unimportant, deserve to be noticed, for the purpose of correcting an error which is repeated even in the most recent descriptions and maps of this country. These are the Atrato, which, rising in the chain of Choco, flows northwards into the Gulf of Darien; and the San Juan, which runs southwards to the Pacific.

It is said that these two rivers were united by the canal of Raspadura, constructed by the Curé of Novita in 1788, and that in the wet season boats pass on it from the one ocean to the other, thus

[1] See Mountain Chains in North America—Geological Division, Map No. 6. From this ridge, the elevation of which is estimated at not more than 1,500 feet above the level of the sea, descends the three greatest rivers of North America, namely, the Mackenzie to the north, the St. Lawrence to the east, and the Mississippi to the south.

[2] From a recent Report by Douglas Houghton, Esq., State Geologist of Michigan, as quoted by Dr. Forry, "Climate of the United States. New York, 1842." The elevations of the lakes, as here stated, differ very considerably from other authorities.

THE RIVER SYSTEMS OF AMERICA,

Extended from the Designs of Professor Berghaus;
WITH THE ADDITION OF DETAILED MAPS
of some of the
principal hydrographical phenomena of the New World
BY
A.K. JOHNSTON, F.R.G.S.

ARCTIC OCEAN
Lancaster Sound
BAFFIN BAY
DAVIS STRAIT
Arctic Circle
Gulf of Boothia
Fox Channel
Cumberland Str.
Frobisher Str.
Hudson Strait
HUDSON BAY
441,600
MACKENZIE
77
73,600
CHURCHILL
12
NORTH SASKATCHEWAN
300,000
61
52,800
ALBANY
9
194,400
COLUMBIA
32
297,600
GT. LAKES & ST. LAWRENCE
56
Missouri
932,400
MISSISSIPPI
Ohio
166
AMERICA
169,200
COLORADO
29
130,000
Rio del NORTE
30
8,000
CONNECTICUT R.
8,700
DELAWARE R.
Columbia or Oregon
Gulf of California
Tropic of Cancer
Mouths of the Mississippi
GULF OF MEXICO
Florida Gulf stream
ATLANTIC OCEAN
CARIBBEAN SEA
7040
MOTAGUA
G. of Honduras
Mosquito G.
G. of Darien
B. of Panama
PACIFIC OCEAN
CANADA
UNITED STATES
CARIBBEAN SEA
72,000
MAGDALENA
12
252,000
ORINOCO
42
61,650
ESSEQUIBO
10
NORTH ATLANTIC OCEAN
Unknown Sources
1,512,000
MARANON
255
284,480
TOCANTINS
48
115,200
PARANAHYBA
19
187,200
S. FRANCISCO
21
Continental Basin of the Andes
Plateau
AMERICA
336,400
LA PLATA
149
Basin of the Lakes
Tropic of Capricorn
SOUTH ATLANTIC OCEAN
G. of San Matias
G. of S. George
G. of Texas
Magalhaen Str.
Str. le Maire
Longitude West from Greenwich

EXPLANATION

In this Map as in the preceding, Nº 5. of this division, the area of the River Basins is stated in Geographical Square Miles, and each is compared with that of the R. Pregel (Prussia) which is reckoned = 1, nearly corresponding with that is the basin of the R. Mobissouri, one of the principal streams in Central America, the extent of which is 7040, while that of the Pregel is 3,920 Sq. Miles. The figures placed over the name of a Basin show the extent of its surface in square miles, and thus under it, its extent as compared with the Pregel. For example, the Basin of the Orinoco is 252,000 Square Miles in extent, and 42 times greater than that of the Pregel. The greater part of these figures can only be considered as an approximation to the truth.

Canals are marked by bold lines, thus ——

Explanation of the Colours Showing the different Oceans &c. to which the Rivers of America contribute their Waters

- District of the Atlantic Ocean
- Pacific Ocean
- G. of Mexico & Caribbean Sea (American Mediterranean)
- Arctic Ocean
- Basins of the Continental Streams

SKETCH of the NIAGARA RIVER Showing the position of THE FALLS

LAKE ONTARIO 234 ft.
Fort George
Queenston
Queenstown Heights
St Davids
Niagara
Great or Horse Shoe Fall 158 ft
NIAGARA FALLS Village of Manchester
Chippewa
Chippewa Creek
GRAND ISLAND
Black Rock
Waterloo
Fort Eric
Buffalo
LAKE ERIE 565 ft.

DELTA of the MISSISSIPPI
The upper ground during the annual inundation is distinguished by light blue tint.
GULF OF MEXICO
New Orleans
Natchez
Vicksburg
Jackson
Baton Rouge
Donaldsonville
Thibodeauville
Terre Bonne
Attakapas
Opelousas
Natchitoches
Alexandria
Monroe
Harrisonburg
Ft Jesup
Ft Phillips
Ft Pike
Ft Wilkinson
Ft Jackson
Ft St Philip
Pass à l'Outre
Balize

MAP of the BIFURCATION of the ORINOCO, or the natural junction of the ORINOCO & MARANON RIVERS by the CASIQUIARE.
The figures indicate heights in feet above the level of the Sea.
Scale 30 miles or 35 Geogr. Miles to 1 Inch.
Geographical Miles.
This Map is on the same scale as that of the Rio Grande.
Comparative Fall of the Rivers Orinoco, Casiquiare & Negro
S. Fernando de Atabapo 750
S. Carlos 312
S. Juan de Maypures 504
S. Juan de Maypures 504
S. Antonio de Javita 504
S. Francisco de Solano 750
S. Antonio de Javita 504
S. Carlos 312
S. Fernando de Atabapo 750
Cassiquiare
Rio Negro
Orinoco

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

uniting two points of the coast, separated by a distance of nearly 300 miles; while the fact is that the canal was never made, the worthy Cacti having only pointed out the possibility of its execution.[1]

Basin of the Magdalena.—The Magdalena rises in the central Cordillera, and flowing northwards, enters the Caribbean Sea by several mouths. The Bogota, one of its affluents, though of little length, is important, from the fact that it waters the plain in which the capital of Columbia stands, and from the magnificent cascade which it forms in its environs.

Basin of the Orinoco.—The Orinoco is one of the three great rivers of South America, and has many affluents equal to the principal streams of Europe, if we except the Volga, the Danube, and the Dnieper. Of its sources little is known, further than that they rise in the mountain system of Parimé. The most interesting of the affluents is the *Cassiquiare*, a branch which, flowing off at a right angle to its south-west, and which, after a course of 120 miles, direct distance, joins the Rio Negro, one of the great affluents of the Marañon, and thus connects the basins of the Orinoco and the Amazonas. This phenomenon will be more fully noticed under the head *Bifurcation of the Orinoco.*

Basin of the Essequibo.—The Essequibo is the largest of the rivers which enter the Atlantic between the Orinoco and the Marañon. It rises in the Sierra Acaray, which separates it from the basin of the Amazonas; and after a course much interrupted by rapids, it discharges itself into the Atlantic by an outlet fourteen miles wide, and separated by three low islands into four different channels. Its principal tributary is the Massarony. Of the sources of the *Demerara* and the *Berbice*, which flow from south to north, nearly parallel to each other, little is known; these both belong to British Guayana. The extensive inland navigation furnished by the numerous rivers of this fertile region greatly enhances its value as a British colony; and Mr. Schomburgk[2] shows, that by means of a portage and a short canal, a water conveyance might be opened between Demerara and Buenos Ayres, over an extent of 42 degrees of latitude, while there is ready communication with Lima, and the Pacific Ocean; and New Grenada, to near Santa Fe de Bogota. British Guayana is separated from the Dutch possessions by the *Corentin.* Very little is known of the rivers in Dutch and French Guayana to the eastward of this river.

Basin of the Marañon.—The Marañon, commonly called the Amazon, is the largest river of the globe; it is formed by the junction of the *Tungaraquet*, or New Marañon, with the *Ucayali*, or *Old Marañon*, the former of which, though inferior in length to the Lake Lauricocha, whence it flows, is the principal branch, and the source of the Marañon; but we think, with M. Balbi, that the Ucayali, formed by the Apurimac, ought to be regarded as the true Marañon.[3] From its junction with the New Marañon to its confluence with the Rio Negro, the river is called the Solimoes, and it is properly called the Amazonas only after receiving the Rio Negro. This immense river is navigable for large vessels as far as the mouth of the Ucayali, where no bottom is found in the middle of the current at a depth of twenty fathoms; and by its means, a navigable passage exists from the Atlantic to within 300 miles of Lima. After leaving the mountains of Maynoviche, this noble stream increases in width from 800 yards to three, and even four miles, before being joined by the Xingu, a river rather inferior to the size of a wide arm of the sea than a river. At its entrance into the Atlantic it forms, with the Para or Rio Tocantins, the large island of Marajo. Among its affluents, it reckons some of the largest rivers in the world.

Basin of the Tocantins.—The River Tocantins is formed by the junction of the Araguay with the Tocantins, the former being the principal branch. It is sometimes erroneously described as an affluent of the Amazonas, with which it communicates by a natural salt-water canal, called the channel of Tagipuru.

Basin of the Paranashyba.—The Paranashyba, or Parahyba, is one of the five principal rivers of Brazil; it is little interrupted by rapids, and is navigable as far as its junction with the Rio Balsas; it enters the sea by five shallow mouths.

The San Francisco, which is another of the chief rivers of Brazil, rises in the Sierra Canastra, province of Minas Geraes, which it traverses from south to north. Its principal affluents are the Velhos and Verde on the right, and the Paraeatu and Rio Grando on the left.

The Rio de la Plata is, properly speaking, only the estuary formed by the junction of the Parana and the Uruguay. The Parana, which rises in Brazil, is the principal branch; it receives on the right the Paraguay, increased by the Pilcomayo, and is called by the Portuguese Rio Paraguay, so named from the salt taste of its waters. The estuary of the Plata increases in width as it approaches the sea from twenty-five to upwards of fifty miles, and on meeting the ocean it is 170 miles wide. Its muddy waters can be traced in the Atlantic for more than 200 miles from its mouth.

To the south of the Plata, the rivers are only two rivers which need be noticed here; these are the *Colorado* and the *Negro*, the courses of which, according to M. Parchappe,[4] are erroneously laid down in all the maps. He says the Rio Colorado, or Mendoza, is formed of two principal branches, one directly from the west, the other from the north; and consequently this river, and not the Rio Negro, must receive the streams which flow from the slopes of the Andes. Notwithstanding the length of its course, the Colorado has but little depth.

The Rio Negro, or Cuneo-Leibu, is the most important river between the Plata and the Strait of Magalhaens. It forms the boundaries between the Pampas and the Plains of Patagonia, and the Nile, says M. Balbi, it has its source in high mountains, and flows in a valley which it waters by periodial inundations; and, like that river also, it flows over a vast extent of country without receiving any affluent—traversing great arid deserts, which are habitable only in the narrow zone fertilised by its waters. But that which most of all renders this river remarkable, is the fact, as stated by M. Parchappe, that it is the only one which can afford a direct water communication between the Atlantic Ocean and Chile, since it conducts to the famous Col of the Andes, which is never closed with snow, and at which terminated a road opened during the first years of the conquest, which led from Buenos Ayres to Valdivia, and which, after a course of 300 miles, reached the towns of Chile. The traces of this route are now entirely lost, and tradition alone preserves the remembrance of it.

On the right the Negro receives a branch, by which it appears to communicate with an extensive system of lakes and marshes, of which nothing is positively known.

Continental Basins of the Pampas.—There are but few rivers in America which do not directly reach the ocean, and these, flowing in elevated table-lands, terminate in lakes, the waters of which are lost by evaporation. Some of these, as we have seen, are situated in Mexico, but the most remarkable occurs in Bolivia, where the Rio Desaguadero flows from Lake Titicaca[5] at the height of 12,795 feet above the level of the sea, and after a course of 360 miles along the valley of the same name, is lost in lakes and swamps. This plateau contains several other smaller rivers and lakes, of which, however, little is known.

To the south of the continental basin, the country forming the western region of the Pampas is drained by a remarkable system of rivers and lakes. The streams flowing from the eastern declivity of the Andes of Chile appear not to reach the sea,[6] but to discharge themselves into a multitude of lakes communicating with one another by different channels. The best known of these lakes is the Guanacache, the most northern, which communicates with Lake Huanacache, and receives the Mendoza, by the Desaguadero into the Bevedero lakes, and through the latter, by the Salado, into Lake Urre-lauquen. The soil of this region is incrustated with saline matter, and the water of the lakes is said to be salt, although the rivers generally have fresh water.

SKETCH OF THE NIAGARA RIVER.

The River Niagara separates the State of New York from the provinces of Upper Canada; it is the outlet of Lake Erie, the surplus waters of which it discharges into Lake Ontario, after a northward course of 335 miles. The surface of Lake Erie is 565 feet, and that of Lake Ontario 232 feet, above the level of the sea, so that the whole descent of the river is 334 feet. The boundaries of the lake begin to contract at Buffalo, where the river is about a quarter of a mile broad; after this it gradually widens, till, dividing into two streams, it sweeps round Grand Island, and, when re-united, the river is considerably increased in volume and rapidity.[7] From Lake Erie to the rapids, within little more than half-a-mile from the falls, the descent of the river is only 15 feet, while in the half mile which intervenes to the head of the falls it is 51 feet. The rapids occupy the whole breadth of the river, from shore to shore. They are formed by the rush of the entire body of water over a rugged bed. Goat Island, about a mile in circumference, divides the falls—the uppermost of which, on the left side, is the Great or Horse-shoe Fall, 155 feet in height, and 1,800 feet broad; and lower down on the right is the American Fall, 164 feet in height, and 900 feet in breadth.

Below the falls, the river banks are nearly perpendicular, and from 250 to 300 feet high. At the distance of about half-a-mile below the Horse-shoe Fall, the river has become so little agitated as to admit of the establishment of a steam ferry across the stream, which is here narrowed to about 1,200 feet. Five miles below the falls, a whirlpool is formed by a sudden turn in the river which checks its course, and forms a dangerous vortex. For about seven miles below the falls the river descends 100 feet, and after passing the Queenstown Heights it enters a plain nearly on a level with Lake Ontario—the whole descent from Queenstown to the Lake being only about four feet. It was long believed, and that at one time the Niagara fell over the abrupt bank at Queenstown, nearly seven miles below the present falls, and that it has, during the course of unknown ages, been wearing its way back to its parent lake. On this subject we must refer to the works of Mr. Lyell,[8] to whom we are indebted for much interesting and accurate information regarding these celebrated falls. "A single general fact," he says, "that the falls do not remain absolutely stationary at the same point of space, and that they have shifted their position slightly during the last half century." And he believes that the river supplies an adequate cause for executing the task assigned to it, provided we grant sufficient time for its completion. Among the circumstances which tend to have been uniform at least for a considerable period, 35,000 years would have been required for the retreat of the falls from Queenstown to their present site. Mr. Lyell adduces evidence to prove the existence of an elevated valley four miles below the falls, and, with great probability, fixes on the position of the "Devil's Hole" as having been the original site of the great cataract. He further shows that the falls have diminished in height as they have receded southward, and that this diminution must necessarily continue, until, if ever, they reach Lake Erie.

DELTA OF THE MISSISSIPPI.

The different forms of river deltas, says M. Elie de Beaumont,[9] appear to be only varieties of the same fundamental type. The phenomena which contribute to their formation, and the process even by which human industry effects them, have everywhere the greatest similarity; and the circumstance that these phenomena present a series of causes almost as marked as those of the development of an organised being, greatly augments the interest of their study.

The Gulf of Mexico offers materials for many curious remarks—it may in some respects be compared to the German Ocean, and especially to the Adriatic Sea; since, though vastly larger, a great part of its coasts completely resembles those which terminate the plains of Lombardy. Like them, they are singularly remarkable for their lagoons, and the delta of the Mississippi recalls, on a grand scale, the delta of the Po.

In the delta of the Mississippi, as in that of the Nile, the Po, &c., the immediate banks of the river are more elevated than the soil at a certain distance from it; hence on both sides there are vast marshes, which exist throughout the year, so that the greater part of the country, from Natchez to the sea, presents only a vast boggy space—the abode of the alligator, and very insalubrious for man. The shore of the sea is covered with salt lagoons, some of which penetrate far into the land, and form true lakes: these lakes are situated generally between the lagoons, and sometimes communicate with, and even traverse them. These lagoons are very shallow, varying from 5 to 10 feet below the general level of the delta.

The delta of the Mississippi commences at the point where the *Atchafalaya* (probably the original bed of the Red River) branches off towards the west; from this point to the sea, at the mouth of the south-east passage, it measures nearly 200 miles—an extent equal to that of the Ganges. The breadth of its base is very considerable, and it forms altogether a triangle somewhat larger than that of the delta of the Nile, the proportions being as four to three nearly. A great part of this triangle, and of the low land adjacent, is constantly covered with water. During the inundation, as shown on the map, nothing remains above this vast temporary lake but a narrow belt along the greater part of the rivers-course. The numerous branches of the river, which bear the generic name of *bayous*, differ in many respects from the river itself; they are of comparatively little depth, and except during the inundation, they carry to the sea only a small portion of the waters of the Mississippi; it often happens, indeed, during summer, that instead of taking water from the river, some of them convey to it the waters they have collected from the marshes of the plain.

The largest of these bayous is the *Atchafalaya*, which discharges a part of its waters into the gulf of the same name, and returns a part to the original trunk, with which all the other branches of the delta are more or less connected. The others are, on the right, the *Plaquemine* and the *Fourche*; and on the left, the *Barrelle*, the *Gentilly*, and the *Iberville*.

Comparing this delta with that of the Nile, M. de Beaumont remarks, that the principal stream of the Mississippi represents, in the Nile delta, the Rosetta branch. The Iberville, which traverses Lakes Maurepas and Pontchartrain, represents the Canopic branch of the Nile, now obliterated, the ancient bed of which separated Lake Madieh from Lake Etko. The Fourche represents the Damietta branch of the Nile, and the Atchafalaya the subordinate Peluziac branch. But we must observe, that such a proportion to any of the others as the principal stream of the Mississippi does to the bayous which are derived from it. The *Anse aux Poirres*, and the other lagoons which extend from it towards Texas, may be compared to those between Peluziums and El Arish. Lake Menzaleh is only imperfectly figured by the Lake of *Chetimoukas*; but the *Part of Barataria* represents Lake Bourlos of the Nile delta, and the *Etang de Valcorea* that of the delta of the Rhone. Finally, the Atchafalaya is to the Mississippi nearly what the Adige is to the Po.

Along the banks of the Mississippi, as on those of the Rhine, the Rhone, and the Po, dykes, here called *levees*, have been constructed, to prevent certain lands from inundation; and these are continued also along the canals and bayous, in which water flows only during the rainy season. The space near Natchez thus reclaimed, by means of dykes erected by the French when they colonized Louisiana, is covered by plantations of cotton and sugar canes.

Pursuing its course directly to the Gulf of Mexico, the Mississippi advances beyond the line of the continent, in a channel which it has formed for itself by the accumulation of mud and drift-wood; and which it gradually extends towards the lower part. For a considerable space above its mouth, the banks present nothing but marshes full of reeds, containing only some fishermen's huts. The principal stream of the Mississippi discharges itself into the sea by several mouths, among which five are remarked, all differing greatly in the number and size of the islands which are formed in them, and by the depth of the channel above their respective bars. The five principal mouths of the river, diverging from a central point, are thus placed at the extremity of as many arms, extending from four to six miles in length. The most important of these is the south-east passage, where the pilots have erected a wooden tower, called Balize. The water on the bars at the mouths of each of these passes is comparatively of little depth, being in the grand pass from 17 to 16 feet, in the south-west passage only 10 feet, and in the others still less. The shallowness of the water on these bars is very remarkable when we compare it with the depth of the Mississippi, which averages from 98 to 130 feet. This furnishes a striking example of the powerful action of the sea in rejecting matters carried to it by the river.

During the inundation, in spring, the lower part of the Mississippi is no longer a river—it becomes a kind of gulf of the sea. The river then itself *towards the south-east* brings with it an immense quantity of wood torn from the borders of the river and its affluents. These trees, mixed with the mud of the river, form the soil of the delta, and daily prolong the promontory which bears to the ocean the waters of the Mississippi. M. de Beaumont calculates the mean annual amount of this prolongation at 1,150 feet, about equal to the rapidity of that of the great Rhone delta of the Po. But he shows, at the same time, that this amazing increase is a temporary, and, so to speak, an artificial phenomenon, produced partly by the dykes by which the river is enclosed, and partly by the system of cultivation of which North America is at present the theatre—that there is no evidence of the solidity of the structure, there being probably nothing permanent either in the extension or its effects; and that the narrow and shifting canal which it has formed affords no solid basis for speculations on the rapid conversion of land in the sea, on which a system has been attempted to be erected. This shifting delta-land does not exceed a square league; and Major Delafield has collected many facts which prove that at certain times there is manifested a prodigious elevatory force in the vicinity of the bar—an upheaval which is doubtless accompanied by a depression elsewhere. Thus, a schooner, having been wrecked, disappeared under water; the top of the mast alone being visible; some time afterwards the vessel was found cast out of the water upon an English shell bank, carried there by the united efforts of land stone, as ballast, to New Orleans, on arriving at the bar, was obliged to cast part of her cargo into the sea, and in a short time afterwards the slabs were likewise found thrown upon an island. M. de Beaumont further shows that there is no ground for the fear that these combined causes will ever succeed in filling up the Gulf of Mexico; the extent of the territory which the Mississippi drain would scarcely suffice to fill its basin; and there is no probability that these countries are to be demolished to their base, and carried off by the waters which flow on their surface, even in the most distant futurity

BIFURCATION OF THE ORINOCO.

America possesses many of those natural canals, the definition of which is sought for in vain in geographical treatises. The most remarkable of these is the *Cassiquiare*, which forms the *bifurcation of the Orinoco* and the union thus formed between the Orinoco and the Amazonas is among the most remarkable phenomena of physical geography. The Orinoco is one of those singular rivers which, after having made many detours to the west and the east, follow at last such a retrograde direction, that their mouth is turned almost in the same meridian as their source. From the river Gheita to the Guaviare, the Orinoco flows to the west, as if it would carry its waters to the Pacific Ocean. Within this space it sends off to the south the remarkable branch called the Cassiquiare, which unites it to the Rio Negro, or, as it is called by the natives, the Guainia; forming an unique example of the junction of two great rivers. The fact of the existence of this natural canal was known to the Portuguese more than half a century ago, but systematic geographers combined in an attempt to prove that such a communication of rivers was impossible; and among others who denied its existence we find *Gumilla*,[10] author of the "Orinoco Illustrado" (1742), who resided three years in the missions in its vicinity; and M. Bouche,[11] in the Colony of Guayana, in 1789. After having long been a subject of doubt, Baron Humboldt set the question at rest by traversing this singular net-work of waters in the year 1800, and it has been more recently explored by Mr. (now Sir) R. Schomburgk.[12] An uninterrupted navigation of 615 leagues, says Baron Humboldt, conducts one from the Rio Negro, by the Cassiquiare, into the Orinoco, or from the frontiers of Brazil, by the interior of the continent, to the coast of Caracas. And further: "Since the year 1767, two or three canoes come annually from the fort of San Carlos, by the bifurcation of the Orinoco to Angostura, to fetch salt and pay the troops. The

HUMBOLDT'S SYSTEM OF THE ISOTHERMAL LINES,

OR

LINES OF EQUAL ANNUAL MEAN TEMPERATURE OVER THE GLOBE,

WITH INDICATIONS OF

THE MEAN STATE OF THE BAROMETER AT THE LEVEL OF THE SEA.

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THE TEMPERATURE IS UNIFORMLY STATED IN DEGREES AND PARTS OF FAHRENHEIT'S SCALE.

INTRODUCTION.

The first person who treated of the subject of *Isothermal lines* was the distinguished traveller, Baron Humboldt, who published an admirable memoir on the subject in 1817, entitled *Des Lignes Isothermes, et de la Distribution de la Chaleur sur le Globe.*[1] This memoir was first made known in this country by Sir David Brewster, who translated it in 1819, and published it with notes in the Edinburgh Philosophical Journal.[2]

The system of *isothermal lines* laid down by Humboldt extended only to the isothermal line of 32° of Fahrenheit, and gave no indication of that extraordinary distribution of temperature which exists in the Arctic regions. The curves of equal temperature approached to the equator in the meridians passing through Canada and the east of Siberia, and receded from it in the meridian of the west of Europe; but no other inference was drawn from this fact, than that the climate of America exceeded in severity that of Europe. Sir John Leslie, indeed, adopting the formula and principles of Mayer, regarded the north pole as the coldest point of the Arctic regions, and fixed its temperature at 33° of Fahrenheit; and even maintained that the average temperature of the Old and New World would be found the same.[3]

In this state of the subject, Sir David Brewster conceived the idea, that there were two poles of maximum cold in each hemisphere, apparently related to the magnetic poles of the globe. In order to put this opinion to the test of observation, he applied to Mr. Scoresby for the results of his meteorological observations in the Greenland seas;[4] and he soon afterwards received, from Sir Charles Giesecke, most copious and valuable observations made in West Greenland, at *Upernavick, Omenak, Godthaven, Julianshaab, and Eygefiord*; and from these and other observations he was led to the conclusion, that the greatest cold at these two poles must be at least 0° of Fahrenheit.

Upon the publication of Sir Edward Parry's observations in the *Hecla*, it appeared that the mean temperature of the parallels of 74° and 75° was — 1° or — 2° or *below Zero* of Fahrenheit.

By combining these observations with many others made in Arctic latitudes, Sir David Brewster concluded that the *Western* or *Canadian* pole of maximum cold was situated in west long. 100°, and in 80° north lat., with a temperature of — 34° Fahrenheit; while the *Eastern* or *Siberian* pole was situated in 200 long. 95°, and in 80° north lat., with a temperature of + 1° Fahrenheit, being 45° warmer than the *Canadian* pole.[5] Hence the isothermal lines must surround these two poles in returning curve lines, the exact form of which can only be determined by observation.

In a letter addressed to Baron Humboldt, an abstract of which was published by that distinguished traveller in Poggendorff's *Annalen der Physik*,[6] Sir David Brewster has given a general formula for calculating the mean temperature at any point of the globe; and according to this formula the curves are of the nature of lemniscates similar to the isodynamic magnetic lines as drawn by Colonel Sabine.[7]

Baron Humboldt, from a comparison of the American and Asiatic observations, had fixed the mean temperature of the equator at 81½° Fahrenheit; but it was obvious, from the existence of two poles of maximum cold, that the points of the equator corresponding to the warm and cold meridians, must have different temperatures, and these, by the aid of numerous observations, were fixed at 81½° for the cold, and 82°.8 for the warm meridians, the mean of which is 82°.15.[8]

Isothermal Lines are curves drawn on a map to connect together all the places on the surface of the globe which have the same annual mean temperature, and this mean is deduced from a comparison of observations made during a series of years. As the average annual amount of heat at the earth's surface depends on latitude, the mean temperature of places situated at the same elevation decreases gradually from the equator towards the poles; but this decrease does not take place regularly, for, as may be seen on the map, the isotherms form convex and concave lines, which diverge more and more from the parallels of latitude as they recede from the equator.

Humboldt[9] explains this, by stating, that whatever causes a variation in the absorbing and radiating powers, in any points situated on equal parallels, produces an inflexion in the isothermal lines. The nature of these inflexions, the angles under which the *isotherms* (or lines of equal annual temperature), the *isotheres* (or lines of equal summer temperature), and the *isochimenes* (or lines of equal winter temperature), cut the circles of latitude, the position of the summits of their convexity or concavity with respect to the pole of the corresponding hemisphere, are effects of causes which modify the temperature more or less powerfully under different geographical latitudes. Comparing, in this manner, Nain on the coast of Labrador with Gröneberg, Halifax with Bordeaux, New York with Naples, San-Augustin in Florida with Cairo, we find that, for the same latitudes, the differences between the mean temperatures of the year in Eastern America, and those of Western Europe, are, proceeding from north to south, 20°.7, 13°.8, 6°.8, and almost 0°. The gradual decrease of these differences, in a series which comprises 28° of latitude, is striking.

Farther south, under the tropics, the isothermal lines are everywhere parallel to the equator. Among the causes which influence the forms of these lines, Humboldt distinguishes those which raise from those which depress the temperature. The first class comprises the proximity of a western coast in the temperate zone; the particular configuration of continents which are divided into numerous peninsulas, mediterraneans, and gulfs penetrating far into the land; the position of a country relative to a sea free from ice extending within the polar circle, or to an extensive continent situated on the same meridian, to the equator, or at least to the interior of the tropical zone; the prevalence of southerly and westerly winds acting on the western side of a continent situated in the temperate zone; chains of mountains which serve as ramparts and screens against winds which come from colder regions; the infrequency of swamps or marshes—the surface of which remains covered with ice in spring, and till the commencement of summer; the absence of woods on a dry sandy soil; the constant serenity of sky during summer; and the vicinity of an oceanic current, if it bring water of a higher temperature than that of the surrounding sea. Among the causes which reduce the mean temperature, he instances elevation above the level of the sea of a region which does not present extensive table-lands; the vicinity of an eastern coast in the higher and middle latitudes; the compact configuration of a continent the coasts of which are not indented by gulfs; a great extension of land towards the pole, and to the region of perpetual ice; and a geographical position such that the tropical regions of the same longitude are occupied by sea—in other terms, the absence of all tropical land on the meridian of the country the climate of which is the object of study; a chain of mountains which, by its form or direction, impedes the access of warm winds, or the vicinity of isolated peaks, which cause the descent of currents of cold air on their declivities; extensive forests, which prevent the action of the sun's rays on the soil—their leaves cause the evaporation of a great quantity of water, by means of their organic activity, and increase the surface exposed to being cooled by radiation, they thus act in three ways: by shade, evaporation, and radiation;—numerous marshes, which, in the north, form, till the middle of summer, true glaciers in the middle of plains; a cloudy summer sky, because it intercepts a part of the sun's rays, and a clear and serene winter sky, which is favourable to the radiation of heat. The inflexions of the isothermal lines are determined by the joint action of all the disturbing causes, while the convex and concave summits of the curves are occasioned by local perturbations. On the difference of temperature between the eastern and western coasts of the old and new continents, and its similarity in the middle latitudes of the west coast of America and the west coast of Europe, Humboldt remarks, that, since the surface of the ocean is not susceptible of being cooled in the same degree as that of the land, it results that, where easterly winds prevail, western coasts should be warmer than eastern coasts, unless modified by oceanic currents. This is exemplified in the difference of temperature between the western coasts of North America, in middle latitudes, and the eastern coasts of Europe. Even in northern latitudes, there exists a very striking difference between the annual mean temperature of the eastern and western coasts of America. At Nain, in Labrador (lat. 57° 10′,) this temperature is 25°.2 or 6°.8 *below* the freezing point, whilst at Neu-Archangelsk, on the north-west coast of Russian America, it is 44°.6 or 12°.6 *above* the freezing point. At the former place, the mean temperature of summer hardly reaches 40°.2, while at the second it is 56°.8. Pekin (lat. 39° 54′,) on the east coast of Asia, has a mean annual temperature of 52°.3, or more than 9° lower than that of Naples, which is situated a little farther north. The mean winter temperature of Pekin is at least 5°.4 *below* Zero; while in Western Europe, at Paris (lat. 48° 50′,) it is 6° *above it*: again, the winters of Pekin are 4°.5 colder than those of Copenhagen, though the latter is situated 17° of altitude farther north.

From the influence of the sea in equalizing temperature, arises the important distinction between the climate of islands, or of the coasts of countries broken up by numerous peninsulas and gulfs, and that of the interior of a great mass of compact land. This contrast is exemplified in Tobolsk, Barnaul, and Irkutsk, in the interior of Asia, which have summers equal to those of Berlin, Münster, and Cherbourg; but to these summers succeed winters in which the severe mean temperature is — 0°.4 to — 4°.0. During the summer months, the thermometer is for entire weeks as high as 86° and 87°.8. This is an example of what Buffon calls an *excessive* climate.

"I have in no part of the world"—continues the illustrious author—"not even in the south of France, in Spain, or in the Canary Islands, seen such magnificent fruit, and especially such fine grapes, as is in the environs of Astrakhan, on the shores of the Caspian Sea (lat. 46° 21′). The mean annual temperature is about 48°; that of summer rises to 70°.2, as at Bordeaux; but both here and at Kislar, at the mouth of the Terek still farther south (in the latitude of Avignon and Rimini), the thermometer in winter falls to — 13° and — 22°."

The climate of Ireland, of the isles of Jersey and Guernsey, of the peninsula of Brittany, the coasts of Normandy, and of Southern England, countries with mild winters and cool cloudy summers, contrasts strikingly with the *continental* climate of the interior of Eastern Europe. On the north-east of Ireland, under the same parallel as Königsberg in Prussia, (lat. 54° 42′,) the myrtle grows in the open air, as in Portugal.

The temperature of the month of August in Hungary is 69°.8; at Dublin, which is situated on the same isothermal line, it is at most 60°.8. The mean winter temperature at Buda descends to 27°.7; at Dublin, where the mean annual temperature is only 49°.2, that of the winter is 39°.8 above Zero; it is 3°.6 higher than at Milan, Pavia, Padua, or than the whole of Lombardy, where the mean temperature of the year rises to 54°.8. At Stromness, in Orkney, a little south of Stockholm, the mean temperature of winter is 39°.2; that is to say, it is milder than at Paris, and nearly as warm as at London. Even in the Färoe Islands (lat. 62°,) under the mild influence of westerly winds and the sea, the waters of the interior never freeze. On the lovely coast of Devonshire, near Salcombe Bay, the *Agave Mexicana* has been seen to blossom in the open air; and orange trees trained against espaliers, although only slightly protected by mats, have borne fruit. There, as at Penzance and Gosport, and at Cherbourg, on the coast of Normandy, the mean winter temperature is 41°.8; hence it is only 2°.4, lower than that of Montpelier and Florence.

These comparisons show in what a variety of ways the same mean annual temperature may be distributed among the different seasons, and what an important influence these different modes of distribution of heat, in the course of a year, exercise on vegetation, agriculture, the ripening of fruits, and the material well-being of Man.

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[1] Memoires de Physique et de Chimie de la Societe D'Arcueil, tom. iii. pp. 462–611. Paris, 1817.
[2] Vol. iii. p. 1, 256, vol. iv. p. 23, 263, vol. v. p. 28.
[3] Edinburgh Encyclopædia, art. *America*, sect. Climate of *America*, vol. i. p. 614.
[4] Mr. Scoresby proved that the mean temperature of the parallel of 80° was 40° Fahrenheit, and that of 78°, 17° F.; and he inferred that the temperature of the North Pole must be at 10°. See Edinburgh Encyclopædia, art. *Polar Regions*, vol. xvii. pp. 15, 16.
[5] Transactions of the Royal Society of Edinburgh, vol. ix. p. 714.
[6] Poggendorff, &c., tom. xxi. p. 325. 1831.
[7] By using observations made at a distance from these poles, our author has given the poles a different position. See Edinburgh Encyclopædia, art. *Variation*, vol. xxiii. p. 213.
[8] Edinburgh Journal of Science, vol. vi. pp. 137, 136; and Edinburgh Encyclopædia, vol. xvii. p. 714, plate 32 of fig. 1.
[9] Recherches sur les Causes des Inflexions des Lignes Isothermes. Asie Centrale, tom. iii. p. 103. Paris, 1843. Kosmos, band. i. Berlin, 1845. French edition translated by Faye. Paris, 1846. The first of these works was made known to the English reader in a comprehensive article, by Sir David Brewster, in the North British Review, August 1846, and the latter in an elegant translation, with additional notes, by Colonel Sabine. London, 1846.

HUMBOLDT'S SYSTEM OF ISOTHERMAL LINES, OR LINES OF EQUAL ANNUAL MEAN TEMPERATURE OVER THE GLOBE:

With Lines of
EQUAL BAROMETRIC PRESSURE
AT THE LEVEL OF THE SEA.

Extracted from the Original Map of
PROFESSOR BERGHAUS.
BY A.K. JOHNSTON, F.R.G.S.

Note.—The Isobares or lines of the mean height of the Barometer at the level of the sea are expressed thus ——(29·90)——

The regions in Siberia, in the Northern Parts of the New World and also in the Southern Hemisphere, coloured blue, show the extent of the permanent frost of the ground.

American Pole of cold
Temp. 32·45 F.

Asiatic Pole of cold
Temp. 4° 73 F.

Isothermal lines.

Thermometer Fahrenheit

Ice Barriers

Line of Permanent Ground Frost

Probable Equator of Temperature

Torrestrial Equator

Tropic of Cancer

Tropic of Capricorn

Arctic Circle

Antarctic Circle

Line of Permanent ground Frost

The Line of Maximum Temperature of the Air.

Coast of the Southern Continent (?) seen by Lieut. Wilkes, of the American Navy, in 1840.

Western Part of the South Continent. (?)

Extraordinary Extension of Drift Ice.

Extraordinary Extension of the antarctic Drift of Ice.

Here the supposed

Line of Permanent Ground Frost

Longitude West from Greenwich

CURVES of HOURLY MEAN TEMPERATURE

Line of mean Temperature 74° 8.

Line of mean Temperature 52.068

Line of mean Temperature 46.232

Line of mean Temperature 42.77

Mn 1 2 3 4 5 6 7 8 9 10 11 Md 1 2 3 4 5 6 7 8 9 10 11 M

Explanation.

The mean Temperature of the Equator of warmth of the air is in Asia 82°8, in Africa 82°1, in the Old World 82°0, in the New Continent 81°0; mean for the Equator of the whole globe 82°4. The figures on the polar side of the Isothermal lines denote the temperature of the winter months. Those on the Equatorial side the temperature of the summer months.

DELINEATION of the Course of THE HOURLY MEDIUM TEMPERATURE of the year in the TEMPERATE ZONE.

Medium of the year.

Mean Temp. of a day 56° 3

Curve of Padua. Lat. 45° 24'

Mean Temp. of a day 46° 9'

Curve of Leith. Lat. 55° 59' 1824-1842

Mn. 1 2 3 4 5 6 7 8 9 10 11 Md. 1 2 3 4 5 6 7 8 9 10 11 M.

South Victoria

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

EXPLANATION OF THE MAP.

In this chart we have given a synoptic view of the course of the isothermal lines, or the lines of equal annual mean temperature over the globe; showing by colours their deviations from the parallels of latitude, and the points of intersection which they form with the meridians. The probable line of maximum temperature of the atmosphere, or the atmospheric thermal equator, it will be observed, does not coincide with the equator of the earth; since it intersects in the northern hemisphere 2.5°, and in the southern, only 10.5° of its circumference. The proportion between the two hemispheres is thus nearly as 1 to 2.3. In the northern, it runs up to lat. 15°; in the southern, only to 9° 30′, a proportion as 1 to 2.3. The points of intersection of the thermal equator with that of the earth are, in the western hemisphere near long. 148° W. in the meridian of the Sandwich Island Hawai; and in the eastern near long. 107° E. in the meridian of Singapore.[1]

Comparing all existing facts relative to the meteorological condition of the warmest regions in the globe, we get the following table of the temperature of the equator at the level of the sea:—

Old World.				New World.		
Asia.			Africa.	America.		
Batavia,	(Lat. 6° 8′ S.)	81°.86	Guinea Coast,	(Lat. 6° 0′ N.)	81°.32	Surinam, Demerara,	} (Lat. 6° 15′ N.)	79°.34
Sunda Strait,	(„ 6 0 S.)	80 .36				Panama,	(„ 8 58 N.)	80 .56
Singapore,	(„ 1 17 N.)	80 .24				Cartagena,	(„ 10 23 N.)	81 .09
Pulo Penang,	(„ 5 25 N.)	82 .34				Cumana,	(„ 10 27 N.)	81 .86
Trincomale,	(„ 8 32 N.)	82 .40	Kaire,	(„ 12 0 N.)	85 .64	La Guayra,	(„ 10 37 N.)	80 .60
Pondicherry,	(„ 11 55 N.)	85 .23	Senegra,	(„ 12 26 N.)	85 .10	Barranquilla,	(„ 11 0 N.)	82 .22
Madras,	(„ 13 5 N.)	81 .50	Senaloo,	(„ 13 5 N.)	85 .46	Santa Marta,	(„ 11 15 N.)	83 .46
Seringapatam,	(„ 12 25 N.)	84 .56	Kouka,	(„ 13 10 N.)	87 .26	Rio Hacha,	(„ 11 40 N.)	82 .35
Bombay,	(„ 18 56 N.)	81 .26	Cobbé,	(„ 14 11 N.)	85 .46	Trinidad, St. Vincent,	} („ 11 30 N.)	79 .16
Mean,		+82°.34	Mean,		+85°.10	Mean,		+80°.56

The data for Asia and Africa, taken together, give the mean temperature of the thermal equator in the Old World as 83°.84. These results entitle us to draw the following conclusions:—

1*st*, The tropical zone in Africa is the hottest on the earth.

2*d*, The torrid zone of the earth in Africa is 2°.2 warmer than Southern Asia, and 4°.2 warmer than the countries on the coast of tropical America.

3*d*, The tropical countries in Asia are 2°.0 warmer than the tropics of America.

4*th*, The tropical countries on the coast of the Old World are 2°.88 warmer than the tropical countries on the coast of the new continents.

5*th*, The tropical zone of the Pacific (where it is free from currents), is 2½° warmer than the corresponding zone of the Atlantic Ocean.

The temperature of the isothermal equator is therefore,

In the Atlantic Ocean, (mean lat. 3°.35′ N.) mean temp. + 82°.40.

In the Pacific Ocean lat. 3°.45′ S.) mean temp. + 84° 20.

As the sea presents a medium which admits of being equally heated, it will be easily understood that when the isothermal lines pass over spaces of the sea at a distance from the continents, they show only trifling deviations and inflexions when compared with the terrestrial parallels. Hence the equal course of the isothermal curves in the South Atlantic, the Indian, and especially in the Pacific Ocean. The inflexion on the coast of South America, is owing to the Chile Peruanie current of cold water.

1. ISOTHERMAL ZONES.

In physical geography, in order to ascertain the zones, we must lay aside the common mathematical instruments, and pay no regard to astronomy. We must confine ourselves to the thermometer, if the question be to ascertain the limits of the zones; that is, the extent of two physical spaces on the globe within two lines of equal average temperature of the year. On this principle the meteorological and climatographical division of the surface of the earth, might perhaps be projected in the following manner:—

Designation.	Limits.	Mean Temperature.
Hot or Equatorial Zone.	Between the Isothermal curves, 77° in both hemispheres.	+ 79°.70
Warm Zone.	Between the Isothermal curves of 77° and 59°.	+ 68°.00
Mild Zone.	Between the Isothermal curves of 59° and 41°.	+ 50°.00
Cool Zone.	Between the Isothermal curves of 41° and 32°.	+ 36°.50
Cold Zone.	Between the Isothermal curves of 32° and 5°.	+ 18°.50
Frigid or Polar Zone.	On this side of the Isothermal curve of 5°.	+ 3°.20

2. LIMITS OF ICE IN NORTHERN AND SOUTHERN HEMISPHERES.

As connected with temperature we have pointed out on the chart the common and occasional limits of the Arctic polar ice in spring, and the line of limit within which it drifts in early summer towards southern latitudes;[2] the extreme southern point at which drift-ice has been found in the North Atlantic Ocean coincides with the parallel of 40° 45′ (long. 50° W.) The most experienced seamen and hydrographers consider the meridian of 40°, or, at most, 42° W., as the easternmost line, where, on the passage between Europe and America, floating masses of ice are to be found;[3] yet it has sometimes happened that farther east they have been the terror of seamen. The permanent and drifting ice of the Arctic regions essentially contributes to depress the isothermal lines on the east coast of North America to such low latitudes, and to increase the difference of the seasons; for whilst, on the European side of the Atlantic Ocean, between the isothermal lines of 41° and 32°, the difference between winter and summer amounts to 36° and 40°, on the other side, on the coast of the New World, it amounts to 32° and 54°.

The situation of the continual *polynia* or sea free from ice in the north of Siberia, is pointed out on the chart according to the statements of Wrangel.[4] This region of the ocean, in which the water preserves its fluidity, commences about sixteen miles north of Kotelnoi, and extends to the meridian of Cape Jackan. The fact of the existence of this open sea in so high a latitude has important bearings on the question of the distribution of heat in the regions of South-eastern Asia; and it is no less interesting when viewed with regard to arctic discovery, since, in the opinion of Colonel Sabine,[5] it indicates the probable existence of open navigable water to the north of Spitzbergen and the Parry Islands. In the southern hemisphere, floating masses of ice come nearer to the terrestrial equator by 5° than in the northern; for whilst in the South Atlantic Ocean they extend to about lat. 35°, the southernmost line of their occurrence in the North Atlantic Ocean does not exceed lat. 40°. But here the warm water of the Gulf Stream assists the temperature of the atmosphere in producing this result. In the Indian Ocean icebergs are frequently observed; one was seen at the Cape of Good Hope[6], on 7th April 1828, by the French vessel *Hermonie*, and the Spanish vessel *Constancia*; it was in lat. 35° 54′ S., long. 15° E.;[7] and on 28th same month and year, the English brig *Eliza*, passed in the same region between floating masses of ice, lat. 37° 32′ S., long. 14° E.[8] These were more than 100 feet above the level of the sea; they were 200 feet in diameter, and the sea broke with great force against them. The appearance of drift-ice in the meridian of the Cape in such low latitudes is so rare an occurrence, that even Horsburgh, the most experienced hydrographer of the time, was astonished at it. Yet it is not without precedent: In 1727, Captain Pitt of the *Stanhope*, in doubling the Cape, in lat. 35° 53′ S., got between floating masses of ice. Dalrymple says: "Islands of ice have been seen sometimes, though rarely, by our ships, in doubling the Cape."[9] The parallel of Rio de la Plata is probably the lowest latitude at which the occurrence of drift-ice has ever been observed in the South Atlantic Ocean.

The parts in the Antarctic Sea where Cook, Biscoe, and Ross, were prevented proceeding further towards the south pole by solid masses of ice, have been pointed out on the map. The extreme points which have been reached by men in their attempts to penetrate to the poles are as follows:—

North Pole.		South Pole.	
Tscitschagoff, 1766, July 28.	Lat. 80° 20′, long. 14° 0′ E.	Biscoe, 1831, February 1.	Lat. 69° 51′, long. 12° 0′ E.
Buchan and Franklin, 1818, July.	Lat. 80° 32′, long. 7° 30′ E.	Bellingshausen, 1821, Jan.	Lat. 70° 0′, long. 92° W.
Phipps, 1773, July 27.	Lat. 80° 48′, long. 21°.	Cook, 1774, Jan. 30.	Lat. 71° 10′ 30, long. 107° W.
Scoresby, 1806, July.	Lat. 81° 30′, long. 18°.	Weddell, 1823, Jan.	Lat. 74° 15′, long. 35° W.
Hudson, 1607, July 9.	Lat. 82° 0′.	Capt. Ross, 24 Feb. 1841.	Lat. 78° 10′, long. 161° 27′ W.
Parry, 1827, July 25.	Lat. 82° 45′, long. 18°.		

In January 1841, Sir James Ross discovered the land to which he gave the name of VICTORIA, lat. 70° 41′ S., long. 173° 36′ E. He describes it as rising in lofty mountain-peaks, from 2,000 to 12,000 feet in height, covered with eternal snow. In lat. 77° 31′ S., long. 167° 1′ E., a magnificent volcano (Mount Erebus), 12,367 feet high, was seen emitting flame and smoke in splendid profusion. The highest southern latitude attained by the expedition was 78° 10′ S., in long. 161° 27′ E.; farther progress was prevented by pack ice.

3. LINES OF EQUAL BAROMETRIC PRESSURE AND CURVES OF EQUAL OSCILLATION OF THE BAROMETER.

The attention of philosophers was first called to the fact that the pressure of the atmosphere, as indicated by the oscillations of the barometer, depends upon the geographical position of the place where the observation is made, by *Alexander von Humboldt*, who observed that the mean height of the barometer, at the level of the sea, is somewhat less under the tropics than in the temperate zone.[1] Since that time *Zach*, *Humeton*, *L. von Buch*, *Muncke*, and others, have imparted to this subject a living interest. *Adolph Erman* has greatly extended the knowledge of these phenomena by a long series of observations in the Atlantic and Pacific Oceans; he discovered that within the zone of the trade winds, constant variations in the mean state of the barometer occur in both hemispheres; that it is always highest at the polar limits, and declines gradually, and with extreme regularity, towards the equatorial limits of the zone.[2] These observations were completely confirmed by *Schouw*,[3] from whose researches we obtain the following view of the mean state of the barometer in the North Atlantic Ocean:—

Latitude.	Height of Barometer at 0° Temperature.	Latitude.	Height of Barometer at 0° Temperature.
0°	29″·853	50°	29″·943
10	29 ·902	55	29 ·960
20	30 ·004	60	29 ·935
30	30 ·069	65	29 ·923
40	30 ·066	70	29 ·722
45	30 ·011	75	29 ·863

From this table it appears that the pressure of the atmosphere reaches its maximum at lat. 30°, and that the amount of difference between that parallel and the equator is 0″.216. Since the limits of the trade winds are variable, and change with the seasons, it follows that the state of the barometer which depends on these, changes also, not according to a constant, but a variable locality. *Erman's* observations made during two years, and at different seasons, show, generally, that the maximum state of the barometer corresponds with the polar limits, and the minimum with the equatorial limits of these winds; but as they do not coincide exactly with these limits, he conceives that the state of the barometer is affected by longitude as well as by latitude. Confining ourselves, however, to the question of latitude, we find that the difference between the two limits in both the trade zones amounts to 0″.2375. Without being aware of Erman's discoveries, *Sir John Herschel* made similar observations on his voyage to the Cape of Good Hope in December 1835, all of which agree in confirming the fact, and give nearly the same amount, namely, 0.25 inch.[4]

The observations referred to by Herschel were made by *Sir E. Ryan* on a voyage from Calcutta to the Cape, and the results, corrected, are entered on the chart; they give the extreme states of the barometer at the equator, and at the 31st parallel of latitude, showing a difference of 0″.34.

From a careful examination of the journal of the Prussian ship, *Princess Louise*, during the circumnavigation of the globe, from 1826 to 1838, *Erman's* discovery is still farther corroborated. The barometer being "always higher at the polar than at the equatorial limits of the trade wind," and the amount of difference also agrees to the tenth part of a line. But the journals of the Prussian voyagers give little support to Erman's opinion, that within the limits of the trade winds in the Atlantic, the height of the mercury in the barometer is influenced by geographical longitude.[5]

It is surprising that the phenomenon of the fall of the barometer between the polar and equatorial limits of the trade wind was not sooner discovered; a comparison of the older ships' journals from the time of Cook would have shown that it had been observed, although no remark was made on its existence. The practical inquiries to navigation may be judged of by the fact, now pretty well ascertained, that if the voyager, within the region of the trade winds, on approaching the belt of the "Variables," observes a depression of the mercury in the barometer to the extent of 0″.29 in the N.E., or of 0″.21 on the S.E. limits, he will immediately lose the benefit of the constant and favourable winds. Nor is their value confined to navigation; they are no less essential in the operations of hypsometry; for as, in measuring heights with the barometer, all determinations of elevation are referred to the absolutely lowest point on the surface of the earth—*i.e.*, to the level of the sea—and as this has been shown to vary with the latitude, it is evidently of the utmost importance that this should form an element in all hypsometric computations.[6]

To these inquiries, which relate chiefly to the North Atlantic and the Indian Oceans, we are now enabled to add the results of the important series of observations made during the voyage of H.M.S. *Erebus* and *Terror*, in the Southern and Antarctic regions under Sir James Clark Ross.[7] The following table, which is derived from hourly observations of the mercury, between the 20th of November 1839, and the 31st of July 1843, shows the mean pressure of the atmosphere at the different parallels between the equator and latitude 74° S.

Latitude	Pressure.	
0	29·874	at sea.
13° 0′ S.	30·016	—
22 17	30·085	—
34 48	30·023	Cape of Good Hope and Sidney.
42 53	29·950	Tasmania.
45 0	29·664	at sea.
49 8	29·469	Kerguelen and Auckland Islands.
51 33	29·497	Falkland Island.
54 26	29·347	at sea.
55 52	29·360	Cape Horn.
60 0	29·114	at sea.
66 0	29·078	—
74 0	28·928	—

"The above results are arranged in belts of latitude, the observations at sea being separated from those made in the harbour; this occasions more apparent irregularity than would have been the case had they been formed into two distinct tables."

These figures (omitting fractions) have been entered at the proper parallels on the chart, which now, for the first time, contains an unbroken series of barometrical measurements, extending from Melville Island on the north, to Victoria Land on the south. Whether the amount of atmospheric pressure at corresponding latitudes in the two hemispheres will form a nearer approximation, on the subject being more thoroughly investigated, remains to be seen; at present that amount seems to be much less in the southern than in the northern hemisphere (see the chart). In the former, at lat. 74° we find a pressure of 28.928; while in the latter, at Melville Island, lat. 74° 45′ it was found to be 29.870; at Igulik, (lat. 69°), 29.770; and at Winter Island, (lat. 69° 11′), 29.708. This, and similar difficulties will, we trust, be elucidated by the very extensive observations now under consideration.

Sir J. Ross remarks, "Our barometrical experiments appear to prove that the atmospheric pressure is considerably less at the equator than near the tropics;" thus adding another testimony to the truth of Erman's discovery. His measurements farther show, that, from the tropic of Capricorn, where the atmospheric pressure is highest, there is a gradual diminution, as the latitude is increased, corresponding with the decrease in the northern hemisphere, as explained by *Schouw*,[8] and exhibited in the chart.

4. LINES ON THE CHART.

In order to prevent confusion, we have left the lines referring to the state of the barometer uncoloured. The *isobares* (or lines of the mean height of the barometer at the level of the sea) are shown by interrupted lines parallel with the equator; and the figures indicating the amount of pressure are placed upon them in a curved line through the Atlantic and Pacific Oceans.

It is very probable that, when the number of observations in Northern Asia and North America have been sufficiently extended, there will be found in the Arctic regions two maximum points of mean barometrical oscillation, as there are two poles of cold.

As the thermometer, in all parts of the globe, and entirely independent of geographical latitude, attains its highest, its lowest, and its mean state on certain days of the year, so we find analogous points in the oscillations of the barometer, on days which very nearly coincide with these.

The barometer is most steady in summer and least so in winter; in its irregular movements it arrives at a mean state twice a year, viz., in spring and autumn.

Compared with similar changes of temperature, we get the following view, deduced from existing observations; and there can be little doubt that if the number of observations were sufficiently extensive the greatest and mean values of both would be found entirely to coincide:—

Oscillations of the Barometer.		Temperature.	
Greatest on the 19th January.		Greatest cold on the 14th January.	
Mean —	18th April.	Mean warmth —	24th April.
Least —	16th July.	Greatest heat —	26th July.
Mean —	18th October.	Mean warmth —	21st October.

These results were ascertained by Kämtz, to whose classical work we beg to refer the student, as the most complete and most interesting system of Meteorology ever produced.[9]

[1] The authorities, from a comparison of which the position of the supposed thermal equator has been deduced, are stated at length in Berghaus, Allgem. Länder-und Völkerkunde, vol. i. Meldrums convictus that there are two lines of equal annual mean temperature, one on each side of the terrestrial equator (Z.)

[2] See chart of the Atlantic Ocean. No. 1, Hydrog. division.

[3] See Rennel, Purdy's Memoir, and Nautical Magazine.

[4] Wrangel's Physikal. Beobachtungen während einer Reisen auf dem Eismeere in den Jahren 1821-23, p. 23.

[5] Wrangel's Polar Sea. Edited by Col. Sabine. London, 1844.

[6] See chart of the Atlantic Ocean. No. 1, Hydrog. division.

[7] Horsburgh's East India Pilot, No. 3.

[8] Horsburgh's East India Directory, vol. ii. pp. 632, 635.

[9] Dalrymple's Memoir on the Southern Ocean, p. 11; Purdy's Oriental Navigator, p. 55.

[10] The meridian at which Hudson reached the parallel of lat. 82° is very uncertain. Kruesenstern, indeed, doubts his having attained so high a latitude.

[1] Essai sur la Géographie des Plantes, Tableau Physique des Régions Equinoxiales, Paris, 1807, p. 90; and Bel. Hist. L. iii. p. 315.

[2] Poggendorff's Annalen der Physik, band. xxii. p. 144. [3] Poggendorff, band. xxvi. p. 405.

[4] Bibl. Univers. de Genève. Mars, 1836, p. 247.

[5] M. Ch. *Martins*, adopting *Erman's* views, says, "The mean pressure of the atmosphere is dependent on the longitude. In equal latitudes it is greater in the Atlantic Ocean than in the Pacific. This result was obtained by the comparison of observations made under 24 different parallels, bearing in mind the influence of the seasons."—*Kämtz Meteorology by Walker*, p. 278.

[6] See researches by M. Dussey in Comptes Rendus, 1836, t. iii. p. 136.

[7] Vol. ii. pp. 304, 305. London, 1842. [8] Comptes Rendus de l'Acad. des Sciences, t. ii., 1836.

[9] Lehrbuch der Meteorologie, 3 band 3, 1831-1836. The subject of the oscillations of the barometer is comprised in sect. vi.

ON THE

GEOGRAPHICAL DISTRIBUTION OF THE CURRENTS OF AIR,

OR OF THE

PERENNIAL, PERIODICAL, AND VARIABLE WINDS.

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INTRODUCTORY NOTE.

CURRENTS of air, or winds, owe their origin to any circumstance which has a tendency to disturb the equilibrium of the atmosphere, as a change in its temperature or in the amount of aqueous vapour which it contains. They may be compared to currents of water which constantly seek to gain an equilibrium, and to fill every space occupied by a less dense fluid. Heat is the principal agent in diminishing the density of bodies, and hence it is the chief cause of atmospheric currents; for experience proves, that wherever two adjoining regions are unequally heated, there is produced an upper current of air proceeding from the warmer to the colder region, and an under current in an opposite direction.

Now this state of matters exists on the surface of the globe, where, as shown on the Map of Isothermal Lines,[1] the mean difference of temperature between the regions of the equator and those of the poles, amounts to upwards of 82°; and as this inequality is nearly permanent, its effect is to produce a constant interchange of air between the polar and the equatorial regions. Thus a cold and dense under current from the poles replaces the rarified air of the equator, which ascending, and forming an upper current, flows towards the north and south, in order to restore the equilibrium of the atmosphere. Hence, if the earth were in a quiescent state, the winds near its surface, in the two hemispheres, would be uniformly due north and south respectively; but the globe revolves on its axis in a direction from west to east, with a velocity increasing from the poles, where it is nothing, to the equator, where it attains a maximum of about 1000 miles an hour; so that in passing from the higher latitudes towards the equator the cold currents of air progressively arrive at regions of increased rotatory velocity; and as they cannot keep pace with this increase of motion, they necessarily hang back and form currents flowing in a direction opposite to that of the rotation of the globe, or from *east* to west, and thus, by the combined effects of the rotation of the globe, and the difference of temperature at its surface, the northern and southern currents are deflected and modified so as to become, respectively, the permanent north-easterly and south-easterly currents, forming the magnificent phenomena of the trade winds.[2]

1. DESCRIPTION OF THE CHART.

This sheet graphically represents the principal phenomena of the winds over the globe. Near the middle of the Chart is the ZONE OF THE VARIABLE WINDS AND CALMS, which, as it forms the climatic centre of the earth, affords a convenient point of departure for our notes on the geographical distribution of the currents of air. Although generally characterized by calms and light variable westerly winds, this belt is visited by sudden squalls and storms, and, as shown on the Hyetographic Map of the World (No. 3 of this division), it is the scene of an almost constant fall of rain, accompanied by electrical explosions. The region of the "variables" varies considerably, both in position and extent, during the different seasons. The mean place of its centre is about lat. 6° N., but it extends farther to the north in summer, when the sun has northern declination, and farther south in winter, when he approaches the tropic of Capricorn; however, it uniformly maintains its position on the north of the equator, never passing to the south of the line—a circumstance which is explained by the peculiar form of the bason of the Atlantic Ocean, the mountainous character of the northern portion of South America, and the current of hot water which enters the Caribbean Sea; the combined tendency of which is to favour the existence of a S.E. wind in these latitudes.[3] Its mean breadth is about 5½ degrees of latitude, but it varies according to the seasons and in different regions from nine to ten degrees. North and south of this belt are the zones of the N.E. and S.E. trade winds in the Atlantic and Pacific Oceans, and beyond them the regions of the N.W. and S.W. currents of air.

The PERENNIAL OR TRADE WINDS extend generally to about 28° on each side of the equator; but, as indicated by the coloured lines on the chart, their limits vary considerably in different parts of the ocean, and being influenced by temperature, they remove two or three degrees farther north or south in proportion as the sun has north or south declination. The equatorial limits of both trade winds are laid down in the chart according to Horsburgh's tables,[4] but the polar limits of the N.E. trade wind are given according to those of Berghaus,[5] and, believing that an accurate knowledge of the monthly variations of the limits of the latter wind would greatly facilitate the navigation between Europe and the West Indies, we have made a careful comparison of the most recent with former observations, and find, for the different seasons of the year, the following results:—January, lat. 23° 24'; February, 28° 39'; March, 27° 19'; April, 28° 18'; May, 28° 31'; June, 31° 23'; July, 29° 36'; August, 31° 11'; September, 32° 4'; October, 25° 38'; November, 27° 14'; December, 22° 15' N. The number of observations is not sufficient to afford correct average valuations of the individual months, but the exceptions balance each other pretty nearly; and, if we group the months according to the seasons, they disappear entirely in the average of the year: we thus get the following table:—

	POLAR LIMIT. N.E. Trade.	EQUATORIAL LIMITS. N.E. Trade.	S.E. Trade.
Winter	Lat. 24° 45'	5° 45'	2° 20' N.
Spring	28	5 45	1 30
Summer	30 45	11 20	3 15
Autumn	28 20	10	3 15
Mean	28°	8° 15'	2° 40'

The N.E. trade wind in the North Atlantic, where the ocean is limited between Cape Verde and the coast of Brazil, blows with less steadiness than the S.E. trade wind on the south of the equator, where it is less confined. Towards the West India Islands the N.E. trade wind generally blows steadily between E. and N.E.

From the vast extent of the Pacific, it has been assumed that the trade winds blow over its surface with greater regularity than in the Atlantic Ocean; but recent observations show that probably not one half of its extent is subject to the continued influence of the trade winds, and that they blow permanently over that portion only, west of the American coast, extending from about the meridian of the Galapagos isles to the 120th or 130th meridian of west long. 20° to 30° N. The numerous groups of islands extending westwards from the Marquesas nearly to Australia, appear to have the effect of changing the trade winds over the western part of the ocean into periodical or monsoon winds. Thus, among the group of the Low islands, the S.E. trade wind is found to prevail only from March to October; and when the sun has southern declination, westerly winds, squalls, and rain begin again, westerly or north-westerly monsoons blow regularly along the shores of New Guinea, New Britain, and New Ireland; and the northern coast of Australia, between Melville island and Cape York, to the parallel of 12° south, may be said to be included in the region of the periodical winds, since at a short distance from the coast, these winds blow with great regularity.[6] "In Torres Strait the N.W. monsoons probably begin from the end of October to the middle of March, and the S.E. trade wind blows lightly during April, and increases in strength till June, during which month and July it often blows very strongly, and then gradually fails again into a gentle breeze."[7]

In the Indian Ocean the S.E. trade wind blows from a few degrees east of the island of Madagascar to the coast of Africa, between the parallels of 10° and 28° S., but from lat. 10° S. to the coasts of India the winds are periodical.

Trade winds are constant only on the ocean at a considerable distance from land, because continents or large islands, and even coral banks, obstruct the regular currents of the atmosphere, and cause either periodical or variable winds. Thus, in the Caribbean Sea, westerly winds, called by the pilots of the country *vendavales* (rainy winds), blow from July to December, and alternate with the sea breezes. From the mouths of the Mississippi to lat. 28° N., N.E. or S.E. winds prevail in the morning from April to July, and in the afternoon the wind turns to S.W. These are called by the Spanish pilots *virazones* (turning winds).

PERIODICAL WINDS OR MONSOONS.—The regular trade winds, which, as noticed above, blow steadily to the south of about lat. 6° N. in the Atlantic Ocean, are interrupted in their course by the peculiar conformation of the land enclosing the basin of the Indian Ocean, on the N.E. and W.; and the predominance of land, combined with the difference of temperature which ensues between it and the sea in its vicinity, gives rise to the phenomena of the *monsoons*—a name derived from the Arabic word "*mausim*," which signifies season. Seasonal winds prevail to a limited extent on many parts of the globe, as in the Gulf of Mexico, where the *norths*, or north winds, blow from September to March;—on the coast of Brazil, where in autumn they blow from the S.E., and in spring from the N.E.; and in the Mediterranean, where the north (*Etesian*) wind attains its greatest strength in summer. In general, the monsoon winds blow in a direction towards the Continents in summer, and away from them in winter. Thus the period of the commencement of the S.W. monsoon, which prevails in the northern part of the Indian Ocean from April to October, corresponds with the season when the sun, having attained great northern declination, has heated the soil of the north of India; whilst in the winter of our hemisphere, when the sun has southern declination, the opposite or N.E. monsoon prevails.

The monsoons blow with greater regularity in the Indian Ocean than in any other part of the globe, especially on the north side of the equator, where they extend from the coast of Africa to the east side of the Bay of Bengal, and even to the China Sea, although in the northern part of the latter they blow with less regularity. On the south of the equator they extend to lat. 7° or 8° S. in the Indian Ocean, but on the coasts of Australia and in the western part of the Pacific, they extend as far as 12° or 14° S.

The monsoons blow during one half of the year, or rather from the middle of April to the middle of September, in one direction in summer, and from the middle of October to the middle of March in an opposite direction. The change of the monsoons occurs between the latter part of March and September, and the early part of April and October, in some places a week or two earlier than in others. This change takes place gradually, and is accompanied by storms and tempests. On the wind ceasing to blow in one direction, the clouds in the upper atmosphere are at once observed to take an opposite course, although several weeks sometimes intervene before the change is apparent on the surface.

These winds penetrate far into the interior of the Continents, but their direction is there modified by the form and contour of the coasts and islands, chains of mountains, and other causes.

The direction of the numerous *lokes* determines the wet and dry seasons in India; the rainy season of the west coast corresponding with the S.W., and that of the east coast with the S.E. monsoon.[8]

PREVALENT WINDS.—Beyond the limits of the trade winds in the temperate climates of both hemispheres, are the regions of the S.W. and N.W. winds. In these regions there is a constant conflict between the under currents proceeding from the poles and the downward returning currents from the equator, in which struggle the equatorial currents have the ascendency; producing in the northern hemisphere the prevailing S.W., and in the southern hemisphere the N.W., currents of air. This return current in the upper regions of the atmosphere is apparent from the movements of the clouds in the vicinity of the tropics, and has been ascertained, by observation, at great elevations. And the prevalence of S.W. winds in the northern hemisphere is proved, not only by the difference of time required in the passage from Europe to the United States—which, on an average of six years' sailing between Liverpool and New York, is shown to be, for the outward passage 40, and for the return 23 days—but also by the numerous observations which have been made in different parts of Europe and North America. The mean direction of the wind deduced from these observations is thus stated by Kämtz:—England, S. 60° W.; France, S. 88° W.; Germany, S. 74° W.; Denmark, S. 62° W.; Sweden, S. 30° W.; Russia, N. 87° W.; North America, S. 86° W. Russia is the only country in which the mean direction is a little to the north of west; but it is admitted that the number of observations is not sufficient to warrant the conclusion that the exception is well founded.

The LAND AND SEA BREEZES, which blow with great regularity on coasts of Continents and islands within the tropics, properly belong to the class of periodical winds.

The sea breeze, which is directed from the sea towards the interior of the land, prevails during the day; and the land breeze, which blows in an opposite direction, during the night. This phenomenon is explained by the unequal heating of the land and the sea. Early in the morning, when the temperature of both is nearly equal, in mild weather, no movement of the air is observed on the coast; but when the sun rises, and the land becomes more heated than the water, the sea breeze commences, gently at first, and gradually increases, till it attains its greatest force at the period of the maximum heat of the day. It gradually declines with the decreasing heat of the evening, and at sunset there is again an interval of calm; but during night, when the land is colder than the sea, the land wind prevails, and attains its greatest force at the period of minimum temperature of the night. These breezes are observed, generally, only within a short distance of the coast.

2. HURRICANES.

Hurricanes occur most frequently within the tropical regions; they are very seldom met with beyond the tropics, or, in the Indian Ocean, nearer the equator than the parallel of 10° S. They are most violent near the tropics, in the vicinity of continents or islands, and they appear to visit the same latitudes with surprising regularity of recurrence. In the northern hemisphere, the focus of the most desolating hurricanes on record has been the region of the West Indies: and in the southern hemisphere, that of the islands of Rodriguez and the Mauritius. (See Chart of the Indian Ocean, Hydrography, No. 2.) On the north side of the equator hurricanes revolve from the east by the north towards the west, from right to left, or in a direction *contrary* to the hands of a watch; and in the southern hemisphere, in an opposite direction, from left to right, or *with* the hands of a watch; or, as explained by Dove, in the northern hemisphere from *right* to *left*, and in the southern hemisphere, N.E., S.W., that is to say, that while the axis of a storm in the North Atlantic Ocean has a progressive motion from the equator obliquely towards the *north pole*. (*See small diagrams A and B on the Chart, in the Indian Ocean and Gulf of Mexico.*)

From the researches of Mr. Redfield[9] and Colonel Reid,[10] we find that the West Indian hurricanes commence near the Leeward islands, travel to the W.N.W., and then round the shores or across the Gulf of Mexico, and, following the Gulf Stream, are lost in the Atlantic between the Bermudas and Halifax. (*See enlarged map on left margin of the Chart.*)

Mr. Piddington[11] says all the hurricanes of the Mauritius and Rodriguez come from the N.E., commencing about the limits of the trade wind and monsoon regions, near Sumatra and Java, that they travel by S.W. and S. returning to the east again.

In the Bay of Bengal, the storms always come from the eastward and travel to the westward; perhaps from the Andaman Islands, as would be found an average track. "There is no instance on record," Mr. Piddington observes, "in which the track comes from the westward of the meridian."

In the West India region, hurricanes occur most frequently in the months of August, September, and October, rarely in June or July.

The season of hurricanes, in the Indian Ocean, south of the equator, is from December to April, or during the hottest months in that hemisphere; they seldom occur in May or November, and in the other seven months of the year tempests are unknown.

The duration of hurricanes in the West India region, as shown by the dates on the map, ranges from June to October, and the average extent is from lat. 10° to 50° N., and long. 50° to 100° W. In the Indian Ocean they have been observed during a period of from 15 to 20 days, and over an extent of 3,000 miles.

The *rate* of motion in a hurricane varies much in different parts of its track. Mr. Piddington calculates, for the Bay of Bengal, a motion of from 3 to 29 miles per hour; and in the China Sea from 7 to 24 miles per hour; and Mr. Thom computes the progression of the centre of the Rodriguez hurricane at from 220 to 270 miles per diem during its early stages, diminishing, as it approached the tropics, to little more than 50 miles. Mr. Redfield and Colonel Reid assume that, in the Atlantic Ocean, hurricanes dilate to 600 or even 1,000 miles in diameter. Mr. Thom states their size in the Indian Ocean to be from 400 to 500, or even 600 miles, at commencement; and the largest size assigned by Mr. Piddington to those in the northern part of the Indian Ocean is 600 miles. The usual size of the vortices in the Bay of Bengal is from 300 to 350 miles, but they sometimes contract from that to 150 miles, augmenting in violence when they do so. The hurricanes in the China Sea seem to be seldom more than from 100 to 250 miles in diameter.

Storm waves appear to be constantly associated with a hurricane, and as such deserving of close investigation. A storm wave is described as a "mass of water of greater or less diameter, according to the storm, raised above the usual level of the ocean by the diminished atmospheric pressure, and perhaps other causes, and driven bodily along with the storm, or before it; and when it reaches bays or river mouths, or other confined situations, causing, by its further rise when constructing, dreadful inundations. The 'storm currents' may be briefly described as circular streams, or the circumferences of rotatory storms." We have thus, in every storm, two sets of forces, independent of that of the wind, acting upon a ship; the one carrying her bodily onward on the track of the storm, and the other drifting her round the periphery of that part of the storm circle in which she may be. Thus, while the current of the storm wave is setting due west, that of the storm current will be west on the north side of the storm circle, and due east on its south side; south at its western edge, and north at its eastern side; and so on in all the intermediate directions.[12]

Atmospheric electricity appears also to be a constant concomitant on hurricanes, although it may frequently escape observation. Of the storms which occurred in the South Indian Ocean, 11 were accompanied by thunder and lightning, while in 21 others no indication of electricity was observed. In the Culloden storm only one instance of electricity was observed among the 13 ships during the several days of the storm, whilst, in the Rodriguez storm of 1843, its presence is noted in some of the logs on almost every day; and Mr. Thom shows, that "electricity is five times more frequently seen on the north than on the south side of the storm, or in that part where the westerly monsoon predominates. Indeed," he continues, "it has been so usual, during a passage from India to the Cape, to see 'lightning in the north-west' ushering in a gale, that Horsburgh says the Dutch commanders of ships had instructions to shorten sail whenever this was observed."

The precipitation of immense quantities of rain appears constantly to accompany storms in the Indian Ocean. For hundreds of miles, on every side of the vortex, there is a dense stratified bed of clouds pouring out rain in torrents without intermission, and this is continued for weeks together. During the Rodriguez hurricane, as well as in every other similar storm, "incessant heavy rain" is repeatedly recorded by the different vessels involved in them.[13]

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[1] No. 1 of this division.

[2] The phenomena of the winds is here stated according to the theory proposed by Halley and Hadley, and adopted by Laplace (Mécanique Céleste, t. vi. p. 240). Herschel, Humboldt, and by nearly all modern writers on meteorology. M. Saigey (Petite Physique du Globe, 1843, p. 207) argues that the inequalities of the soil alone influence the inferior beds of the atmosphere; and Mr. Hopkins (on Atmospheric Changes, 1844), attempts to trace all the phenomena of the winds to the evaporation of water and the condensation of steam.

[3] See Notes on the Temperature of the Atlantic Ocean, Hydrology, page 5.

[4] India Directory, vol. i., p. 26, fifth edition.

[5] Allgem. L. U. V. K., vol. i., p. 206.

[6] Surveys of the *Beagle*, Captain J. L. Stokes, 1846.—App. p. 330.

[7] Voyage of H.M.S. *Fly*, vol. i., p. 152.

[8] See Notes on the Rain Map of the World, No. 4 of this division.

[9] Silliman's American Journal, vol. xx. 1831. See also for 1835, 1846, &c.

[10] Attempt to Develop the Law of Storms, London, 1838.

[11] Inquiry into the Nature and Course of Storms, London, 1845.

[12] Horn Book of Storms, Calcutta, 1844.

[13] Horn Book, pp. 20, 21. † Inquiry, &c., pp. 167–189.

GEOGRAPHICAL DISTRIBUTION OF THE CURRENTS OF AIR

OR OF THE PERENNIAL, PERIODICAL AND VARIABLE WINDS.

Showing also

THE VARIOUS REGIONS OF PREVALENT HURRICANES:

Extended from the Original Map of

PROFESSOR BERGHAUS.

BY A.K. JOHNSTON, F.R.G.S.

Explanation

Hurricanes and Typhons are represented thus ——————

The opening of the sign —— *indicates the mean direction of the Wind.*

(See Region of Monsoons and District of Hurricanes on Chart of the Indian Ocean. Hydrology Nº 2)

NOTE

The red line ——— *shows the course of the Hurricane and the stars the rate of its daily progress. The arrows indicate the direction of the wind, both within and outside of the storm circles.*

(See Region of Hurricanes in Chart of Indian Ocean. Hydrog. division Nº 2.)

Rodriguez Hurricane April 1843

Track of the Storm

Region of the S.E. Trade Wind

Bridgewater Storm

Tropic of Capricorn

CHART OF THE RODRIGUEZ HURRICANE In April 1843. FROM Mr THOMS' Inquiry into the Nature and Course of Storms IN THE INDIAN OCEAN.

Note.

This Map has been compiled chiefly from Original Journals, and from observations and remarks made during a series of twenty years navigation to and from America, and round the world by the various ships of the Royal Prussian Mercantile Navy. The Author has also made use of the very valuable works of the English Hydrographers, especially of the Index Directory of his late lamented friend Capt. James Horsburgh of the Hon. Mr John Purdy &c. &c. The Meteorological Papers of Professors Dove, Forbes, Kämtz, and the Works of Redfield, Reid, Piddington & Thom. on Storms, have also contributed largely to its construction.

REGION OF THE SOUTHWESTERLY CURRENTS OF AIR

or of the downward returning North Eastern Trade Wind in triumphal Conflict with the Northern Polar Currents

REGION OF THE NORTH EASTERN TRADE WIND AND CALMS

REGION OF THE SOUTH EASTERN PERENNIAL OR TRADE WIND AND CALMS

REGION OF THE N.W. CURRENTS OF AIR

or of the downward returning South Eastern Trade Wind in triumphal conflict with the Southern Polar Currents

ZONE OF THE VARIABLE WINDS

REGION OF THE MONSOONS

On the North Side of the Equator prevails the N.E. Monsoon from April to Oct. the S.W. Monsoon from Oct. to April

On the South Side of the Equator prevails the S.E. Monsoon from April to Oct. the N.W. Monsoon from Oct. to April

Direction of the wind in the North Atlantic Ocean

The probable Axis of the great Storm in November 1836

Stormy Region of the Gulf Stream

District of the West Indian Hurricanes

The Tornado-Track of the Hurricanes

The North-western Coast of America

The Mountains of the Mexican Coast

District of brisk winds veering from E. to N.E. to S.W. in every season between the parallels of 27½-35°

The Stormy Region of Cape Horn

Region of the Rebecos or Pampero

The Monsoons of the Pampero

Diagram W.I. Hurricanes

Mean Direction of prevalent Winds in S. summer and W. winter, in the Regions of the South Easterly Currents of air.

Nº 1

Nº 2

Nº 3 BAROMETRICAL COMPASS

Showing the effect of the turning of Wind upon the Barometer.

Northern Hemisphere

Southern Hemisphere

According to the rule first explained by Professor Dove, Member of the Royal Academy of Sciences, Berlin, the wind, in Polar and Equatorial

LIMITS of the TRADE WINDS in the SEASONS.

Nº 4 THERMOMETRICAL COMPASS

Showing the effect of the turning of Wind upon the Thermometer.

Currents of air alternate together, turns from S. to W. S.E. and S. within the Northern Hemisphere, but from S. to S.E. W. and S. within the Southern Hemisphere.

MAP of the Regions of the WEST INDIAN HURRICANES by Mr Redfield of New York.

Chart of the CULLODEN'S HURRICANE In March 1809. and the BOYNE'S GALE In 1835.

By Lieut. Colonel W. Reid R.E. (See Chart of Indian Ocean)

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

The barometer and simpiesometer are invaluable instruments in the hands of a skilful mariner while navigating these hurricane regions; the only chance of safety, indeed, lies in a close attention to their indications. Mr. Thom asserts, that in these regions no unusual fall of the mercurial column ever takes place without being followed by a storm; nor is there any well authenticated case on record, where a tempest, within or near the tropics, was not preceded by a diminution of the pressure of the atmosphere. When the barometer is in good order, it will never fail to indicate the approach of a rotatory storm—the only kind that occurs, or, at least, that need be apprehended, in the track of the trade wind. Mr. Redfield remarks, that "the barometer sinks under the first half of the storm in every part of its track, and rises during the passage of the last portion of the gale;" a circumstance which is thus explained by Mr. Thom: "It would seem," he says, "that the depression of the barometer begins to take place by slow degrees from the extreme limits of the circle, but increases, in a sort of geometrical progression, as the distance from the focus is lessened; and, near the latter position, the descent and subsequent rise take place so suddenly as to describe an acute angle." As a means of ascertaining the movements of a hurricane, and enabling the navigator to escape its violence, we must not omit to mention Mr. Piddington's ingenious application of Colonel Reid's storm cards.

West Indian Hurricanes. *(See small map on left hand corner of the Plate.)*—The materials for the map of the regions of the West Indian hurricanes are derived from Mr. Redfield's valuable work. As delineated on the chart, the track of the greater portion of these hurricanes appears to form part of an elliptical or parabolic circuit, and they present the very striking fact, that the vortex of the curve is uniformly found in or near the parallel of latitude 20°; which parallel also marks the external limits of the trade winds on both sides of the equator. It is further worthy of remark, that by the parallel of 30°, the surface area of the globe, as well as its atmospheric covering, is equally divided; the area between this latitude and the equator being nearly equal to that of the entire surface between it and the pole. It is observed by Purdy,[1] that whereas one vessel had been exposed to the storm on one side, another, which was only 90 geographical miles distant, had been attacked by it quite in the opposite direction. This statement is, according to Redfield, to be understood thus: that the two vessels had got into the two opposite parts of the same hurricane, where the wind, in its regular revolution round its axis, must, of course, blow from different regions of the horizon.

Suppose one vessel in A, the other in B *(see diagram* No. 1), on their way from W to K, the hurricane attacks the first vessel in the direction indicated by the arrow, at the point C, a direction which will be easterly if the hurricane takes place in the temperate zone, on this side of the parallel of lat. 30°. Now, it is evident that as the hurricane continues in its N.E. course, the vessel will have to intersect the body of the storm on the line C, A, D. As the hurricane continues, the wind revolves northwards, as pointed out in the diagram by the arrows. It is N.E. when the vessel is in A, and near the close, or in the eastern progress of the hurricane; the wind has also revolved further round the direction pointed out by D, and which we may fix in N.N.W., taking into account the progressive movement of the hurricane. The second vessel, as is also evident, will be attacked by the storm first from the south, or on the point E, from which direction it will blow without great change, till the vessel, in the progress of the hurricane, has reached the point B. The barometer, which had fallen before, will now begin to rise, and the wind, in turning farther westward, will, in the progress of the hurricane, blow from the direction of F, which, taking into account the progressive movement of the hurricane, will be W.N.W. These are the principal points of experience commonly made by vessels which happen to get into the lateral parts of one of the West Indian hurricanes. It will easily be seen, that the opposite winds, which prevail in the two different lines of intersection of the hurricanes, might very naturally be taken for two different winds. The phases of the winds in these hurricanes will, however, in all cases, be more or less modified by the course of the vessel, or by the changed position which it assumes. If, for instance, a vessel receives the hurricane from E.S.E. in the point h, and lies with the prow northwards, it may, by this circumstance, be enabled to intersect the hurricane in the line h, i, and may, on the point i, suddenly be taken from behind by the wind from N.N.W. And if we look once more at the diagram, it will show us that a third vessel, which is on the point G, may indeed be exposed to a very high wind from S. and W., may, however, because it is outside of the region of the hurricane, suffer nothing from its violence, whilst only a few miles off it rages with the greatest fury. It has been said that the course of a hurricane may be in the direction from W. to E.; but Redfield has distinctly shown that this opinion rested on a misunderstanding of the observations, that the hurricane, as long as it blows south or north of the Tropic of Cancer, yet in the neighbourhood of it, or, to express it more accurately, as long as it remains within the limits of the trade winds, varies always from E. to W., and still its course describes a curve towards the parallel of 30° N., where it is described first towards the north, and then towards the east. The direction which has been taken by thirteen hurricanes, as delineated on the map, shows this most accurately.

One of the most dreadful hurricanes on record in the temperate zone, whether on account of the injury which it caused, or the extraordinary extent to which it raged, was that of November 1826. According to the best information, it began in America, crossed the Atlantic, and reached the European coast in the parallel of the English Channel.[2] *(See probable area on the Chart.)* The first accurate account shows it on the 23d November, on the east coast of North America, in the parallel of the St. Lawrence. An English vessel from Poole happened to get into its course on the 26th, in lat. 47° N., long. 32° 20′ W. It continued its way over the Atlantic, and approached Land's End, lat. 50° 4′ N., long. 5° 41′ W., on the 29th November, at 7¾ A.M.; it was at Plymouth at 8½; Exeter at 9½; in Weymouth at 10½; Poole, 10½; in Farnham at 12 noon; London, at 12½ P.M.; on the coast of Suffolk, at Flushing, and the Island of Walcheren, at 1 P.M.; in Düsseldorf at 2 P.M.; in Hamburg and Berlin, at 6 P.M.; in Königsberg, at 9 P.M. It appears to have lost its power in proceeding to the interior of the Continent of Europe, and to have ceased altogether in Lithuania. This hurricane travelled at an average rate of 50 miles per hour—the rotatory movement of the wind had a velocity of from 120 to 150 miles per hour. The storm raged most on the coasts of France and Belgium; at Ostend scarcely a house was left unroofed, and the demand for tiles in consequence became so great, that the price for 1,000 rose from 16 to 30 florins: the devastations made during its progress in the north of Germany were of a similar kind. The oscillations of the mercury during this hurricane deserve to be particularly noticed. In London, the barometer was, on the 29th, at 9 A.M., at 29.30 English inches; it soon began to fall very fast, and showed great fluctuation during the violent gusts of wind by which this hurricane was particularly distinguished from others; at 12 noon the column of mercury had fallen to 28.82; at 2 P.M. it had risen to 29.35; soon afterwards the wind subsided, and was followed by a calm.

CHRONOLOGICAL TABLE OF THE PRINCIPAL HURRICANES WHICH HAVE OCCURRED IN THE WEST INDIES, WITHIN 150 YEARS.

Date of Occurrence.		Localities Visited.	Date of Occurrence.		Localities Visited.
1673, August	21.	Barbadoes.	1809, August	3.	Porto Rico and St. Domingo.*
1681,		Antigua.	1812, August	14.	
1707,		Antigua.	1812, October	12.	Jamaica.
1712, August	28.	Jamaica.	1813, August	18.	Jamaica.
1722, August	29.	Jamaica.	1814, Oct. 10 and	19.	Jamaica.
1726, October	22.	Jamaica.	1816, Sept. 10 to	12.	Cayenne, Island and Campeche.
1740,		Antigua.	1818, September	19.	Alleyela, St. Domingo.
1751, October	29.	Jamaica.	1818, September	19.	Barbadoes and Jamaica.
1751, September	2.	Jamaica.	1818, Sept. 22 to	25.	Windward of Antigua.
1766, August	13.	St. Domingo.	1819, October	7.	Port Royal, Jamaica.
1772,		Antigua.	1821,		Barbadoes.
1780, October	3.	Savanna-la-Mar (Jamaica). (XI.)*	1821, September	1.	Bahamas, Carolina, Massachusetts, &c. (VIII.)
1780, October	10.	Barbadoes. Martinique. Porto Rico, Hayti, Bermuda. (XII.)	1827, August	17.	St. Martin and St. Thomas. (III.)
1781, August	1.	Jamaica.	1830, August	12.	St. Thomas. (V.)
1781, July	28.	Jamaica.	1830, August	13.	On the S. of the Bahamas. (IX.)
1785, August	27.	Jamaica.	1830, September	28.	On the north side of the Caribbee Islands. (VII.)
1786, October	20.	Jamaica.	1831, June	22.	Trinidad, Tobago, and Grenada. (I.)
1791, October	20.	Jamaica.	1831, August	18.	Barbadoes. (II.)
1795, August	1.	Antigua.	1835, August	12.	Antigua, Nevis, St. Kitts, St. Thomas. (V.)
1804, September	3.	Antigua, &c. (IX.)	1835, September	3.	Barbadoes.
1804, September	19.	Barbadoes.	1837, August	7.	Barbadoes, St. Vincent, St. Lucia, and Martinique.
1805, July	25.	On the north side of the Bahamas.	1837, July	26.	Antigua, St. Thomas, &c. (XIV.)
1806, September		In the neighbourhood of the Bahamas.	1837, August	2.	Antigua, St. Thomas, &c. (XIV.)
1807, October	14.	Between Jamaica and Santa Maria.	1837, August 5 to	25.	St. Kitts or Little Antilles. (XV.)

* The roman numerals refer to the hurricanes the courses of which are delineated on the map.

We find from the map that the months of August, September, and October, is the season of the hurricanes; yet we see from the above table, that whirlwinds may also happen, although very rarely, in the months of June and July. We have, during 157 years, in June, 1 hurricane.

July,	4
August,	17
September,	11
October,	10

Altogether 43, exclusive of six, the month of the occurrence of which has not been ascertained. It is evident from the above list, that the month of August has the greatest chance in favour of a hurricane, but it might lead to the supposition that hurricanes have been more numerous within the last half century, especially since the great hurricane in 1780. This increase, however, is only apparent, for the great difference in the number of hurricanes recorded during the two periods, before and after 1780, is evidently owing to the greater accuracy with which these phenomena have been noted down in recent times. It has hitherto been supposed that the islands of Trinidad, Tobago, and Grenada, are exempt from hurricanes, but the year 1831 has shown the contrary, for among them we find the first, and till now the only instance, of a hurricane in the month of June.

[1] Atlantic Mercury, 7th edition, p. 86. London, 1835.
[2] White's Meteorological Retrospect for 1836, in "London Magazine."

On the Culloden Storm. *(See Chart on right-hand corner of the Plate.)*—Colonel Reid has given a most satisfactory description of this hurricane in his "attempt to develop the law of storms." As the original is too long for insertion here, we shall merely give a summary, extracted from an able article on this subject in the "Edinburgh Review," vol. lxviii., p. 427, by Sir David Brewster:—

"This storm was experienced in March 1809 by the East India fleet, under the convoy of the *Culloden* line-of-battle-ship. Four of the Company's ships, and H.M. brig of war *Harrier*, foundered in this storm; the details of which are peculiarly interesting and pregnant with instruction. At the Court of Inquiry which investigated these losses, most of the commanders speak of two distinct storms; but Colonel Reid has shown that the second alone existed, and traced the course of the parabolic route of the storm, into which the *Huddart* sailed, after crossing the narrow and peaceful area which was interposed between the two branches. In this pacific spot, the *William Pitt*, *Harrier*, and *Euphrates*, enjoyed two days of fine weather in consequence of lying to; and a similar advantage was enjoyed by the *Northumberland*, *Ixion*, and *Sovereign*, which, by lying to, got out of the violence of the hurricane. The *Sir William Bensley*, on the contrary, and the *Sir Vincent*, by running a day's sail n-head of the above seven ships, involved themselves in fresh misfortunes; and the former was hence compelled to lie to on the 17th for 21 hours, under bare poles. The *Culloden* and the *Terpsichore* frigate scudded like the *Bensley*, and the four missing Indiamen followed her. The *Culloden* stood on, and got out of the storm on the 18th, while the *Terpsichore*, in consequence of having lain to on the 15th for 16 hours, was longer exposed to danger. The *four* missing ships were all seen on the 15th, and if they had put before the wind, they must have rushed into the heart of the storm and perished." For further accounts of the Culloden Hurricane and the Boyne's Gale, see the "Law of Storms."

Rodriguez Hurricane. *(See Chart at top of Plate.)*—Mr. Thom conceives that more favourable circumstances for studying the nature of hurricanes cannot be expected, than those in which he traced out the course of that under consideration. In following up his inquiries, he has strictly adhered to a statement of facts, and the result has been, a striking confirmation of the fact of the rotatory movement of hurricanes; and the direction of their revolution, from *east* to *west* by *south*, in accordance with the view of Mr. Redfield and Colonel Reid. A series of diagrams were projected, showing the positions of the vessels involved in the storm, and the direction of the wind at noon each day. From the veering of the wind, and the state of the weather, &c., obtained by examining the logbooks, and the general direction of the arrows indicating that of the wind, a point was fixed on as the probable focus of the hurricane, round which concentric lines were drawn enclosing all the arrows. *(See the Chart.)* When this was done for each day, the centres were ascertained and transferred to their proper positions on the chart, when it was found that the foci occupied a regular curving line, extending from lat. 10° S. to the southern tropic, and that they were separated from each other by intermediate distances, gradually diminishing in length as the track diverged from the equator.

This hurricane was first discovered about the 28th March, in long. 86° E., lat. 10° or 11° S., and it was finally lost sight of about the 12th April, in long. 58° E., lat. 28° S., having thus travelled along the ordinary route in 15 or 16 days. Its diurnal rate of progression is computed at about 220 or 230 miles, during its early stages, diminishing till, on nearing the tropic, it was little more than 50 miles. Want of space prevents our pursuing these interesting inquiries further; but ample details will be found in Mr. Thom's valuable work on the "Nature and Course of Storms in the Indian Ocean." London, 1845.

Typoons.—The region of these storms, as pointed out in the chart, extends from about lat. 10° to 30° N., and from the coast of China to about long. 150° E. Their mean tracks, for the six months from June to November, in which they occur, are, according to Mr. Piddington, as follow:—

June, from E. to N. westward.
July, from between N.E. and S.E. by E. to N. westward.
Aug., from between E. and S. 40° E., to the W. and N. westward.
Sept., from between N. 60° E. to S. 10° E. to the S. westward, and N. by westward.
Oct., from between N. 12° E., and S. 45° E., to the S. by westward, and N. westward.
Nov., from between N.E., and to the S. westward and N.E., to the S. westward.

They seldom occur oftener than once in three or four years, and their approach seems to be generally indicated by the appearance of the sky and the state of the barometer. In the description of the typoon which visited Hong Kong, 21st to 26th July 1841, Commander Hall says:[1] "For some days previously, large black masses of clouds appeared to settle upon the hills on either side; the atmosphere was extremely sultry and oppressive; the most vivid lightning shot incessantly along the dense, threatening clouds, and looked the more brilliant, because the phenomena were always most remarkable at night, while, during the day, the threatening appearances were moderated considerably, and sometimes almost entirely disappeared. The vibrations of the mercury in the barometer were constant and rapid; and although it occasionally rose, still the improvement was only temporary, the storm was therefore confidently expected to burst more so, because none had occurred for several years. Between seven and eight o'clock in the morning, the wind was blowing very hard from the northward, or directly upon the shores of Hong Kong, and continued to increase in heavy squalls hour after hour. Ships were already beginning to drive, and the work of destruction had commenced on every side; the Chinese junks and boats were blown about in all directions, and one of them was seen to founder with all hands on board. The fine basin of Hong Kong was gradually covered with the scattered wrecks of the war of elements; planks, spars, broken boats, and various beings, clinging hopelessly for succour to every trencherous log, were tossed about on every side; the wind howled, and tore everything away before it, literally sweeping the face of the waters. From half-past ten until two the hurricane was at its highest, the barometer at this time having descended to nearly 28, 50′, according to some, but on board the *Nemesis* it was never lower than 28° 80′. The air was filled with spray and salt, so that it was impossible to see more than a few yards from the ship's side, and the wind howled fearfully, so that it was impossible to hear a word that was said. Ships were now drifting foul of each other in all directions; masts were being cut away; and, from the strength of the wind, forcing the sea high upon the shore, several ships were driven high and dry. The native Chinese were all distracted, imploring their gods in vain for help. Such an awful scene of destruction and ruin is rarely witnessed. Numbers of the natives were seen so busy in thinking of their gods as to be unable to render assistance to any one else. Hundreds of Chinese were drowned, and occasionally a whole family, children and all, floated past the ships, clinging, in apparent apathy (perhaps under the influence of opium) to the last remnants of their shattered boats, which soon tumbled to pieces, and left them to their fate. Five days afterwards, on the 26th, there was a recurrence of the typoon, which the *Nemesis* rode out very easily in the Tyes anchorage at Macao; but it was not so severe as the first one, and comparatively little injury was caused by it."

Within the district of the typoons, the Philippine Islands are visited by the peculiar storms called by the Spaniards *tempestados* and by the Indians *capaics*; during the prevalence of which the wind passes successively through all the points of the compass, constituting dreadful hurricanes, which devastate the fields, uproot the largest trees, overturn houses, and drive the shipping on shore.[2]

Local Storm Regions.—The principal regions of storms are, as we have seen, confined to the vicinity of the West India Islands on the north, and the Indian Ocean on the south, of the equator; but, besides these, many less extensive districts on the globe are periodically visited by storms of more or less violence. Among the districts where storms are of very frequent occurrence, may be noticed the region of the Gulf Stream in the Atlantic Ocean; the zone of the variable winds between the N.E. and S.E. trade winds; and the vicinity of Cape Horn: while the regions of the trade winds *in the open sea* are remarkably free from storms.

It is to the trade winds that the most peculiar qualities correspondent with the regions whence they proceed; thus, those which come from the deserts of Asia and Africa, are characterized by being excessively hot and dry. The best known of these is the *samoom* or *simoom*—the *samiel* of the Turks, (from *samma*, hot or poisonous) which, under different names, prevails in many parts of Northern Africa and Arabia. On the coast of Guinea, where it is called *harmattan*, it blows in December, January, and February, sometimes three or four times in a week, continues from one to three days, and sometimes even to fifteen days. During its prevalence the sun is obscured, the verdure of plants is changed into a dull blue, birds and animals are agitated and restless, and the skin of the human body becomes dry and inflamed. In Egypt the hot wind is called *khamsin* (fifty), because it continues for about fifty days, from the commencement of the inundation of the Nile in April till June.

What are called *foehns* in Switzerland, are usually attributed to the *Sahara*;[3] but Kämtz is of opinion that they arise in the plains of Andalusia or on the rocks of Sicily.

Explanation of the Diagrams.—Besides the principal map, this sheet contains three smaller maps and three diagrams. The maps and diagram No. 1, are referred to above. Diagram No. 2, at the foot of the sheet, shows the limits of the trade winds in the Atlantic Ocean in the four seasons. The trade winds, as is well known, follow the declination of the sun, therefore in summer it rises higher towards the pole than in winter. The seasons of the northern hemisphere are opposed to those of the south, consequently we must read in the latter diagram, in southern latitudes, instead of winter, *summer*; instead of spring, *autumn*, &c. Taking this into account, we see that the polar limit of the S.E. trade wind has not yet been accurately ascertained by observation, for it should have in summer a higher latitude than in autumn and spring, and should in winter be nearest to the equator. Diagrams Nos. 3, 4, show the effect of the rotation of the wind on the barometer and thermometer. The vane is, as Dove has so beautifully demonstrated, the true regulator of the weather. In the temperate zones there is a continual interchange of polar and equatorial currents—*i. e.*, together with the trade winds, the wind turns, in a certain sense, through the directions of the compass—in the northern hemisphere, from north through east, south, and west; in the southern hemisphere, however, from south, through east, north, and west. This is the phenomenon which is called by Dove (Gesetz der Drehung) the law of rotation, which is simply founded on the theoretical observation, that currents of air depend on temperature, as is confirmed by all observations. From this it is evident, that the changes of the principal meteorological instruments, viz., the barometer, thermometer, and hygrometer, are nothing but the faithful expression of the law of rotation; the effects of which law are explained by the arrows in the respective wind-roses or compasses.

[1] Voyage of the Nemesis: London, 1844.
[2] Las Philippines, par J. Mallat, t. i. p. 109; 1846.

HYETOGRAPHIC

OR

RAIN MAP OF THE WORLD.

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INTRODUCTION.

Among hydro-meteors, rain forms the most important climatic element; hence an inquiry into the quantity precipitated in the various parts of the globe, and its distribution among the different seasons, has an important bearing on many departments of physical science.

The life of plants and animals depends as much on moisture as on temperature, and their development is greatly modified by the dryness or humidity of the atmosphere.

Rain is very unequally distributed over the different regions of the globe. It is, in general, most abundant in those latitudes where evaporation takes place most rapidly; yet there are exceptions to this rule. In many parts of the earth it almost never rains, because, as Kämtz remarks, the greatly heated atmosphere does not contain sufficient moisture to admit of precipitation, even during the greatest decrement of temperature.

The rainless districts of the earth comprise extensive regions almost devoid of vegetation, as the great Desert of Sahara, and that of Gobi or Shamo, and the arid shores of Peru. On the contrary, there are regions where it constantly rains, and these are generally in the vicinity of the sea; thus, in the British territory on the western coast of Africa upwards of 300 inches of rain have frequently fallen during one rainy season alone. From the examination of existing observations, the following general laws have been deduced :—

I. Rain is, in general, most abundant at the equator, and the quantity decreases in a direction towards the poles; because heat, which is the origin of vapour, and the cause of rain, decreases in the same direction.

As stated in a note on the map, this decrease occurs in the following order :—

The annual amount of rain under the tropics of the New World is	113 inches.	In the temperate zone of the New World (United States),	37 inches.
The annual amount of rain under the tropics of the Old World,	76 "	In the temperate zone of the Old World (Europe),	31½ "
Within the tropics generally,	95½ "	Average within the temperate zone,	34½ "

From the Island of Haiti, in the Antilles, to Uleaborg in Finland, the annual amount of rain decreases from about 150 to 13 inches.

The number of rainy days, on the contrary, increases with the latitude or distance from the equator; so that, in general, the days on which it rains are fewest where the fall of rain is greatest.

II. The amount of rain decreases in general in ascending from low plains to elevated lands. But, on the contrary, it increases in ascending from plains to the slopes of mountains, especially if these consist of steep and rugged mountain chains; and the influence of elevation is so great that, while at Paris the annual fall of rain is 20 inches, the average annual depth on the Mountain of Great St Bernard is 63.13 inches. Steep and rugged mountain chains promote, through partial currents of air, the formation and increase of clouds; hence mountain chains of this form are more cloudy and rainy than those with smooth slopes and uniform summits. The general law of decrease from low to high lands is observed when these consist of table-lands surrounded by border mountains; because the latter present little or no material for the formation of vapour, having already precipitated the passing clouds; hence, table-lands are characterized by great dryness.

Chilan and Mazanderan, two provinces of Persia, on the Caspian Sea, in the low coast-plain at the foot of Mount Elbrus, are distinguished by the great amount of rain with which they are visited; whilst on the table-land of Iran (2,500–3,000 feet high) a cloud is hardly ever known to disturb the serenity of the atmosphere, and the brightest metal exposed to the open air is not rusted.

III. The quantity of rain decreases as we recede from the coasts to the interior of continents; which is occasioned by the greater amount of vapour that arises from the sea than from the land, and because between land and sea there is a greater interchange of heat, and consequently a greater movement in the aërial currents, than between different parts of a continent, especially if it be not mountainous. This rule is apparent in the interior of the United States of North America, in the centre of the plains of the Orinoco, in the steppes of Siberia, and in the interior of Australia (where the air is very dry), as well as in the countries between the tropics. There are, however, many exceptions to this rule, depending on the geographical position of countries in relation to the regions of winds and the directions of the mountain chains. Thus, a mountain chain may be the cause of moisture to one country, and of drought to another in its vicinity—of the former, when the country in question is situated on the side of the mountains against which the rain winds commonly blow; and of the latter, when it is situated on the other side of these mountains.

IV. In the temperate zone of both hemispheres, the western coasts are proportionally more moist than the eastern, because they are exposed to westerly currents of air, which, passing over the ocean, are highly impregnated with moisture. Within the tropics, on the contrary, the eastern coasts, especially those of the New World, are more moist than the western, from their exposure to the trade winds.

V. Seasons of Rain.—In different parts of the earth we recognise certain limits within which it rains more at one season than another.

(1.) We find, north of the rainless district of Africa (latitude 35° north), a district in which it almost never rains in summer; probably because the ascending currents of warm air from the Sahara prevent the formation of rain in the upper strata of the atmosphere. In the other three seasons, on the contrary, the precipitation is very copious, especially in winter. This district, which may therefore be called the *province of the winter rains*, includes the insular groups of Madeira, the northern part of Africa, the southern part of Spain and Portugal, the Island of Sicily, the southern part of Italy, the whole of Greece, and the north-western part of Asia.

(2.) North of this province, the whole of southern and western Europe, belongs to the *province of the autumn rains*; that is to say, in this province, which embraces northern and western Scandinavia, the British Isles, the delta of the Rhine, the western part of France, and all the southern part of Europe south of the Carpathians, the amount of rain which falls in the three autumn months exceeds that of the other three seasons.

(3.) North and east of this district lies the *province of the summer rains*, including the eastern parts of France, the Netherlands, except the Rhine delta, the north of Switzerland, the whole of Germany north of the Alps and Carpathians, Denmark and southern Scandinavia, as well as the whole of central Europe, and the countries beyond the Ural Mountains to the interior of Siberia, where showers are as rare in the winter as they are on the coasts of the Mediterranean in the summer months. At Nertchinsk whole months pass away in winter without a shower falling; and this is the case also at Irkutsk and Yakutsk. From the end of autumn till the month of April not a cloud is to be seen here; and the sun rises as it sets, perfectly serene and bright. In this division of atmospheric precipitation among the different seasons in the temperate zone, we recognise the difference between the maritime and continental climates: in the former the winter and autumn, in the latter the summer, rains prevail.

(4.) The proportions of rain in the different seasons on the eastern coast of the Old World cannot be specified, for want of a sufficient number of observations; but on the western coasts of the New World we find that the Aleutian Isles, which are on the same parallel as the north of Germany, have fixed winter rains; at Oonalashka there are seasons in which rain has been observed to fall during the whole winter. On the north-west coast of America there seems to be no fixed season of rain. The Island of Sitka, which is in the same parallel as the north point of Jütland, had, in the year 1828, no fewer than one hundred and twenty days of uninterrupted rain or snow, and only sixty-six days which could be said to be perfectly fair; indeed, there have been years in which only forty dry days have been observed. This almost incessant precipitation on the north-west coast appears to be changed into a winter rain in the interior of North America; and this again merges into the summer rain which prevails on the eastern coasts of the United States.

(5.) In the Southern Hemisphere, in Chile and the south-western part of America, winter is the rainy season, whilst on the eastern side of the Cordilleras the rains occur in summer; but farther south, in Tierra del Fuego and the extreme point of the continent, the two provinces meet—the periodical precipitation disappears, and it rains and snows throughout the year with a violence resembling the torrents of the tropics. At Cape Hoorn, a quantity of rain was collected in forty-one days, which measured the astonishing depth of 153.75 inches. This excessive fall of rain occurs along the whole western shores of Patagonia, from Magalhaen's Strait to Cape Tres Montes; a condition which is favoured by the height and ruggedness of the coasts, and the incessant westerly winds, which carry the vapour collected from the ocean to be here precipitated in the form of rain.

(6.) Southern Africa, and Australia beyond the tropics, suffer from great droughts, which, in the latter case, is periodical, and, as far as can be yet ascertained, recurs in the countries of the eastern coasts in a period of about twelve years, and sometimes continues for three years, during which time very little, indeed almost no rain falls. In other respects, however, the regions of Southern Africa and Australia resemble each other in their rainy seasons, which, in both, occur during the autumn and winter months.

(7.) The next consideration is the frequency of the fall of rain in different parts of the earth. When the yearly amount of rain falls in numerous small quantities, its effect on climate is very different from that produced by few and heavy showers. The annual amount of rain at the equator is 95 inches, and this falls in seventy-eight or eighty days, averaging about 1.14 inch daily; while at St Petersburg the annual amount is 17 inches, which falls in one hundred and sixty-nine days, averaging for each rainy day, little more than 0.1 inch. This position will be more fully exemplified in the notes to the Rain Map of Europe.

DESCRIPTION OF THE MAP.

The statistics of the amount of rain which falls in extra European countries are too few, and the stations at which they have been made are too much isolated, to admit of anything more, in this first attempt to construct a Rain Map of the World, than the most general indications. The carefully registered observations of many years will be necessary, before we can venture to draw on the chart of the world curves of equal quantities of rain similar to those delineated on the Map of Europe, which forms the next sheet of this division.

The principle adopted in the construction of this map is that of light and shadow—the light spaces on the map indicate the total absence, or great paucity of rain, and the shaded parts indicate an amount of rain proportioned to the depth of shadow. The darker the shading, therefore, so much greater is the amount of rain. The space within the tropics, with some exceptions, is the darkest, and the shading is, in general, lighter (not reckoning the rainless districts) the farther we recede from the equator.

I.—ZONE OF THE PERIODICAL RAINS.

Coloured Orange tint *on the Map.*

Within the tropics, one half of the year is characterized by extreme moisture, and the other by drought. The rainy season follows the apparent course of the sun. On the north of the equator the period of rain prevails as long as the sun has northern declination; on the south side of the equator, the rainy season begins as soon as the sun has passed into the Southern Hemisphere. Generally the rainy season occurs to a given place under the tropics when the sun forms the smallest angle with its zenith.

In countries situated between 5° and 10° of latitude north and south, where there is a longer interval between the periods of the passage of the zenith, there are two rainy and two dry seasons. The greatest of these lasts three or four months, and occurs at the time when the sun passes over the zenith, in its progress to the nearest tropic. The other occurs when the sun approaches the parallel of the place, on its return from the nearest tropic, when the rains are much less copious, and last only from six weeks to two months; towards the tropics these merge into the regular rainy seasons. The quantity of water which falls between the tropics in a month is greater than that of a whole year in Europe; but the rain does not fall, as is erroneously supposed, for continuous days without interruption; indeed a day of uninterrupted rain is more rare in tropical countries than in Europe. Notwithstanding local causes, the phenomena succeed each other with great regularity. The sun rises generally in a clear sky; clouds appear two hours before noon, and at noon the rains set in, frequently pouring in torrents for four or five hours; but at sunset the clouds quickly disappear, the rains cease, and not a drop falls during the night. At the commencement of the rainy season the low countries are frequently covered with water to a depth of ten or twelve inches, which loads the atmosphere with vapours, and causes those exhalations so detrimental to health. In the open sea, within the zone of the trade or passage winds, it never, or at least very seldom rains; but the narrow zone between the trade winds, characterized by variable winds in the Atlantic and Pacific Oceans,[1] is the scene of very frequent, indeed an almost constant, falling of rain, accompanied by electric explosions. The countries within this zone appear never to be many days together without rain; and the rainy season is here only distinguished from other seasons by the more constant and more abundant fall of rain.

India offers a remarkable exception to this order of the seasons—the rainy and dry season not being there regulated by the position of the sun, but by the direction of the monsoons and the position of the coast lands. The western coasts are watered by the south-west monsoon, which prevails from April to October, and the eastern by the north-east monsoon, from October to April.

These circumstances prevail over all the countries of the Indian Sea—on the one side to Madagascar and the eastern coast of Africa, and on the other to the northern district of Australia. When the wind, blowing from the south-west, is forced to ascend the slopes of the Ghauts, the vapours condense on their summits, and violent storms occur almost daily. The greatest amount of rain falls in the month of July. During the south-west monsoon it seldom rains in the interior, and the sky is serene on the eastern coasts.

The same circumstances take place on the coast of Coromandel during the north-east monsoon, but as the mountains are less steep, the rains are not so abundant; while it continues to rain on the east coast, the western coast enjoys a clear and unclouded sky. Some places in the middle of the peninsula have partial rains throughout the year, whilst the table-land of the Deccan participates in the climate of both coasts.

The influence of the monsoons reaches to the border of the Himalaya Mountains, and far into the interior of China, so that even Otrea is included in this district. In the western regions of these interior countries, in Upper India and Western China, the rainy season prevails during the south-west, and in Eastern China, during the north-east monsoon. In the Southern Hemisphere the rainy season corresponds with the south-west monsoon, whilst the south-east monsoon forms the dry season. In Africa the periodical rains do not reach the Tropic of Cancer, their limits being found on the southern border of the Sahara, and in the middle of Nubia, about 16° north latitude. Near the equator the rainy season commences in April. Between latitude 10° north and the Tropic of Cancer, especially in the countries watered by the Senegal, it lasts from the beginning of June to November. In the New World, the tropic itself forms the limit of the periodical rains; yet a great part of the western coast of tropical America, the Peruvian coast, is seldom or never visited by rain, because the rain clouds discharge themselves on the eastern side of the high chain of the Andes.

At Panama, the rainy season commences early in March; while at San Blas, in California, it seldom begins till the middle of June. The coasts of Chile and Patagonia are visited by heavy winter rains; while the eastern coast, from the Tropic of Capricorn to Tierra del Fuego, has only light rains in summer.

[1] See Map of the Winds, No. 2 of this Division.

HYETOGRAPHIC OR RAIN MAP OF THE WORLD.

EXTENDED FROM THE ORIGINAL DESIGNS OF PROFESSOR BERGHAUS, BERLIN;

BY A. KEITH JOHNSTON, F.R.G.S.

NORTHERN ZONE OF CONSTANT PRECIPITATION

SOUTHERN ZONE OF CONSTANT PRECIPITATION

ZONE OF THE PERIODICAL RAIN

Zone of Frequent, almost Constant Precipitation, always accompanied by Electrical Explosions

Tropic of Cancer

Tropic of Capricorn

EQUATOR

Isothermal limit of the fall of Snow

Greenland

Spitzbergen

Iceland

Lapland

SIBERIA

Finland

Canada

UN. STATES

Mexico

WEST INDIES

Cuba

Jamaica

Haiti

Virgin Is

Barbadoes

Trinidad

Panama

Venezuela

New Granada

Ecuador

Peru

Brazil

Guyana

Cayenne

Galapagos Is

Sandwich Is

Mendaña Is

Navigator Is

Tonga Is

Society Is

Low Islands

Pitcairns I.

Easter I.

Sala y Gomez

Chatham I.

Europe

Ireland

England

France

Germany

Prussia

Poland

Denmark

Hungary

Turkey

Italy

Spain

Portugal

Azores

Madeira

Canary Is

Asia Minor

Syria

Persia

Turkestan

Mongolia

Tibet

Hindustan or India

Beloochistan

Arabia

Nubia

Soudan

Abyssinia

Socotra

Senegambia

C. Verde Is

Congo

Benguela

Ascension

St Helena

Trinidad

Rio Janeiro

Tristan da Cunha

Falkland Is

Tierra del Fuego

C. Horn

South Georgia

Sandwich Land

Powell's Group

South Shetland

Graham Land

Cape Colony

Madagascar

Mauritius

Bourbon

Sumatra

Java

Borneo

Celebes

Gilolo

Luzon

Philippine Is

Formosa

China

Japan

Corea

Manchouria

Yakutsk

Irkutsk

Archangel

Petersburg

Moscow

Tekaterinburg

Aleutian Is

Sitka

Behring's Str.

Labrador

Newfoundland

New York

Washington

Charleston

Florida

Havana

Vera Cruz

Guatimala

Panama

Lambayeque

Callao

Valparaiso

Mendoza

Buenos Ayres

La Plata

Paraguay

Patagonia

Chile

Bolivia

Peru

Winter Rain

Summer Rain

Constant Rain

Constant Precipitation

Mid Summer Rain

Autumn and Winter Rains

Australia

New South Wales

Sydney

Van Diemen's Land

New Zealand

New Guinea

New Ireland

New Hebrides

New Caledonia

Fiji Is

Marianne Is

Carolines Is

Marshall

Gilbert Is

Amsterdam

St Paul

Kerguelen Land

Enderby Land

Adelie

Balleny Is

Aleutian Is

Kurile Is

Japan

Formosa

Corea

Xiphon

Canton

Macao

Calcutta

Benares

Delhi

Bombay

Mahabaleshwar

Ceylon

Maldives

Laccadives

Comoro Is

Zanzibar

Mozambique

Socotra

Gondar

Gallas

Ajan

Timbuctoo

Gambia

Sierra Leone

Liberia

Ivory Coast

Gold Coast

Guinea

Dahomey

Benin

Bonny

Cameroons

Fernando Po

Gaboon

Loango

Angola

Benguela

Mozambique

Madagascar

Mauritius

Bourbon

Natal

Cape Colony

Orange River

Transvaal

Kalahari

Namaqua

Damara

Ovampo

Mossamedes

Congo

Zaire

Nile

Abyssinia

Gondar

Gallas

Ajan

Socotra

Red Sea

Arabian Gulf

Persian Gulf

Caspian Sea

Black Sea

Mediterranean Sea

Baltic Sea

Gulf of Bothnia

Gulf of Finland

White Sea

Behring's Str.

Sea of Okhotsk

Kamtschatka

Aleutian Is

Sitka

Behring's Str.

Labrador

Newfoundland

Greenland

Iceland

Spitzbergen

Nova Zembla

Lapland

Finland

Sweden

Norway

Denmark

Ireland

England

France

Germany

Prussia

Poland

Hungary

Turkey

Italy

Spain

Portugal

Azores

Madeira

Canary Is

Asia Minor

Syria

Persia

Turkestan

Mongolia

Tibet

Hindustan or India

Beloochistan

Arabia

Nubia

Soudan

Abyssinia

Socotra

Senegambia

C. Verde Is

Congo

Benguela

Ascension

St Helena

Trinidad

Rio Janeiro

Tristan da Cunha

Falkland Is

Tierra del Fuego

C. Horn

South Georgia

Sandwich Land

Powell's Group

South Shetland

Graham Land

Cape Colony

Madagascar

Mauritius

Bourbon

Sumatra

Java

Borneo

Celebes

Gilolo

Luzon

Philippine Is

Formosa

China

Japan

Corea

Manchouria

Yakutsk

Irkutsk

Archangel

Petersburg

Moscow

Tekaterinburg

Aleutian Is

Sitka

Behring's Str.

Labrador

Newfoundland

New York

Washington

Charleston

Florida

Havana

Vera Cruz

Guatimala

Panama

Lambayeque

Callao

Valparaiso

Mendoza

Buenos Ayres

La Plata

Paraguay

Patagonia

Chile

Bolivia

Peru

Winter Rain

Summer Rain

Constant Rain

Constant Precipitation

Mid Summer Rain

Autumn and Winter Rains

Australia

New South Wales

Sydney

Van Diemen's Land

New Zealand

New Guinea

New Ireland

New Hebrides

New Caledonia

Fiji Is

Marianne Is

Carolines Is

Marshall

Gilbert Is

Amsterdam

St Paul

Kerguelen Land

Enderby Land

Adelie

Balleny Is

Aleutian Is

Kurile Is

Japan

Formosa

Corea

Xiphon

Canton

Macao

Calcutta

Benares

Delhi

Bombay

Mahabaleshwar

Ceylon

Maldives

Laccadives

Comoro Is

Zanzibar

Mozambique

Socotra

Gondar

Gallas

Ajan

Timbuctoo

Gambia

Sierra Leone

Liberia

Ivory Coast

Gold Coast

Guinea

Dahomey

Benin

Bonny

Cameroons

Fernando Po

Gaboon

Loango

Angola

Benguela

Mozambique

Madagascar

Mauritius

Bourbon

Natal

Cape Colony

Orange River

Transvaal

Kalahari

Namaqua

Damara

Ovampo

Mossamedes

Congo

Zaire

Nile

Abyssinia

Gondar

Gallas

Ajan

Socotra

Red Sea

Arabian Gulf

Persian Gulf

Caspian Sea

Black Sea

Mediterranean Sea

Baltic Sea

Gulf of Bothnia

Gulf of Finland

White Sea

Behring's Str.

Sea of Okhotsk

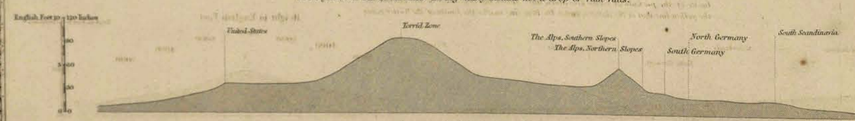
Kamtschatka

S.E. Monsoon from April to Oct. N.W. Monsoon from Oct. to April.

S.W. Monsoon from April to October. N.E. Monsoon from October to April.

NOTE

The zones of constant precipitation are so named in order to distinguish them from the zones of periodical rains. In the former it does or may rain during every day in the year, whereas in the latter during many months not a drop of rain falls.



Amount of Rain in the Zones

Decrease from the Equator to the Poles

The amount of Moisture is indicated by shading which is darker in proportion as the quantity of Rain is greater. The annual amount is distributed as follows

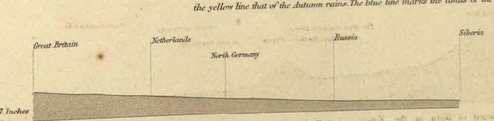
Under the Tropics of the New World	115 Inches	In the temperate zone of the New World (Un. States)	37 Inches
Under the Tropics of the Old World	76 "	In the temperate zone of the Old World (Europe)	32½ "
Within the Tropics generally	95½ "	Average within the temperate zone	34½ "

The greatest amount of Rain hitherto observed was at Mahabaleshwar Western Ghauts, Lat. 18° N. 240½ Inches

Matumba (Guadaloupe) Lat. 16° N. 235¾ Inches

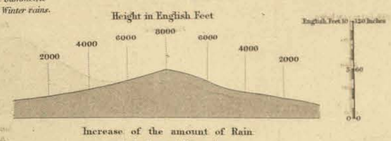
EXPLANATION OF THE COLOURS

The red lines on each side of the tropics mark the equatorial limits of the zones of constant precipitation. The orange coloured lines shew the Northern & Southern limits of the periodical rains. The green line shews the boundary of the Summer, & the yellow line that of the Autumn rains. The blue line marks the limits of the Winter rains.



Decrease of the amount of Rain

From the coasts to the interior of continents.



Increase of the amount of Rain

On the Slopes of Mountains.

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

II.—ZONES OF CONSTANT PRECIPITATION.

In the regions beyond the tropics, the periodical rains disappear, and are succeeded by the rains which occur throughout the whole year. We have designated the extra-tropical regions "zones of constant precipitation," to distinguish them from the regions of the periodical rains: in the former it does or may rain during every day of the year, and the rains are probably as common during the night as in the day; whereas in the latter, during many months, not a drop of rain falls, and even in the rainy season the nights are perfectly dry. Between the tropics, the greatest quantity of rain falls when the sun is at the zenith, or in the season corresponding to our summer, while north of the tropics the greatest amount falls in winter. Designating the annual amount of precipitation by 100, we find the relative quantities of rain, in the different seasons of the year, as follows:—

	Per Cent.
Winter,	50.6
Spring	16.3
Summer,	2.8
Autumn,	30.3

The same relative quantities are found on the north-west coast of Africa and the Canary Isles. This remarkable contrast between the seasons is a sudden, not a gradual transition, as may at first be imagined. "I insist on this fact," says Kämtz, "to show how completely it is at variance with the assertion hazarded by the old meteorologists." The cause of this sudden change may frequently be recognised in the mixture of a volume of air of different temperatures—variable winds often occasioning this mixture. In summer, the regular east winds extend to the coast of Portugal;[1] this produces less disturbance in the equilibrium of the atmosphere, and consequently clouds are more rarely formed than during the variable winds of winter.

III.—RAINLESS DISTRICTS.

The immense tracts marked "Rainless Districts" on the map extend on both sides of the equator; near the tropics, they form a belt round the globe, interrupted only by mountain ranges. In some of these districts a drop of rain is never known to fall; and in others, it is known only at long intervals, and in very small quantities.

The most extensive of these districts is that which stretches from the borders of Morocco eastward through the desert of Africa, the low coasts of Arabia, Iran or Persia, and the desert province of Meckran in Beloochistan, occupying a space of 80° of longitude by 17° of latitude, or about three millions of square miles.

The next comprises the great Desert of Shamo or Gobi, the table-land of Thibet, and part of Mongolia—an extent which we may estimate at about two millions of square miles; and the third, comprising different portions of America, may be reckoned at about half a million of square miles.

In the New World, the rainless district on the north of the equator embraces the table-land of Mexico, and a part of Guatimala and California. On the south of the equator it extends along the western declivity of the Andes of Peru, towards the Pacific Ocean. The absence of rain in this tract is accounted for from the circumstance that the clouds, driven by the passage winds, discharge themselves on the eastern declivities of the Cordilleras. From the total want of rain, and the entire absence of electrical explosions, the inhabitants of the coast, in spite of the guasa,[2] boastingly speak of "la serenidad perpetua del Peru" (the perpetual serenity of Peru).

The inhabitants of Lower Peru see lightning on the distant sides of the Cordilleras; but they are as little acquainted with the roll of thunder as are the inhabitants of Greenland.[3]

From the light style of building their houses, the Peruvians would feel the effects of rain more than that of an earthquake; when such a phenomenon is so rare on the coasts that it appears scarcely two or three times in a century, it may well be supposed capable of alarming the careless inhabitants of the tropics.

Great destruction was caused by the fall of rain in Lower Peru in the years 1701, 1720 (January), and especially in 1728 (February and March), when rain fell, almost without interruption, for forty days in the plains at the foot of the Cordilleras, and even on the coasts. The rain was accompanied by thunder, and occasioned epidemics among the people of the country.

In the year 1790, in the little town of Lambayeque, at the northern part of the Wilderness of Peru, several houses fell during a shower of rain of a few hours' continuance: these, however, were built so lightly as more to resemble the card-houses of children than dwelling-places for social use; such anomalies, which have also been remarked in the delta of Egypt and at Cairo, throw important light on the extraordinary meteorology of Lower Peru.

It would be interesting accurately to ascertain the total amount of rain which is precipitated by the atmosphere over the whole world in the course of a year. The following calculation gives the approximate result as nearly as our present amount of knowledge on the subject will permit:—

Within the tropics the mean annual fall of rain is about 8.50 feet, in the temperate zones 3.05 ft., and in the frigid zones 1.25 ft. But the *area* of the torrid zone may be represented by 4 nearly; that of the sum of the two temperate zones by 5, and that of the two frigid zones by 1. Now, proportioning the fall to these numbers representing the respective surfaces, the general mean for the whole earth will be five feet of depth of fall, very nearly. This mean depth would give one hundred and eighty-six thousand two hundred and forty cubic imperial miles of water, or seven hundred and sixty billions, or, as this is sometimes expressed, seven hundred and sixty millions of millions of tuns of water for the total annual fall of rain on the surface of the globe; which result is considerably strengthened by the experiments of the celebrated Dr Halley on evaporation.

All existing observations have been collected and brought into one view in the following table. The figures express, in detail, what the map represents, horizontally by means of shading, and perpendicularly by the assistance of the diagrams at the foot of the sheet.

IV.—LIMITS OF THE FALL OF SNOW.

At the level of the sea between the tropics, and even far beyond them, precipitation in the form of snow is unknown. In the western part of the Old World, the equatorial limit of the fall of snow nearly coincides with the parallel of 36° north latitude, so that it includes the whole of Europe.

In the New World it follows nearly the same line, extending through the southern part of the United States. In the Southern Hemisphere, the equatorial limit of the fall of snow appears to correspond with the parallel of 48° south. Snow, as might be expected, increases in a northerly direction; but it also increases in the direction from west to east—the farther we proceed from the Atlantic Ocean, so much more abundant is the fall of snow. This subject will be more fully explained in the notes to the Rain Map of Europe.

V.—TABLE OF THE AVERAGE ANNUAL AMOUNT OF RAIN IN DIFFERENT PLACES OVER THE GLOBE.

I.—YEARLY AMOUNT OF RAIN WITHIN THE TROPICS.

1. Old World.

Place of Observation.	Latitude.	Height in feet.	Plains. Amount in Eng. inches.	Mountains. Amount in Eng. inches.
Pulo Pinang, South-east Peninsula,	5° 25′ N.	...	63.00	123.62
Province Wellesley, opposite Pulo Pinang,	5 22	...	78.96	...
Pulo Pinang, Flagstaff Hill,	5 25	2245	...	113.00
Colombo, Ceylon,	6 57	...	99.21	...
Kandy, Ceylon,	7 18	1653	...	84.22
Christiansborg, Guinea,	5 30	...	19.20	...
Sierra Leone, Guinea,	8 30	...	189.69	...
Nilgherries, Indiap	11 30	7992	...	62.97
Unnamund, on the Nilgherries,	11 35	7354	...	44.77
Andeharakandy, Malabar,	11 40	...	122.67	...
Gondar, Abyssinia,	12 36	7407	...	37.38
Seringapatam, Plateau of Mysore,	12 45	2413	...	29.47
Bangalore, Plateau of Mysore,	12 55	3197	...	43.72
Madras, Coromandel,	13 05	...	48.94	...
Darwar, Table-Land of Deccan,	16 28	2398	...	25.64
Mahabuleswar, Western Ghauts,	17 59	4497	...	302.66
Puna, Deccan,	18 31	1822	...	22.49
Bombay, Malabar,	18 56	...	80.94	...
Port Louis, Mauritius,	20 10 S.	...	25.25	...
Macao, China,	22 10 N.	...	68.30	...
Calcutta, Bengal,	22 35	...	58.68	...
Canton, China,	23 08	...	63.28	...
Bauoorah, Bengal,	23 20	...	54.33	...
Dacca, Bengal,	23 43	...	69.38	...
Benares, India,	25 19	319	42.73	...
Cathmandoo, or Khatmandu, Nepaul,	27 42	4641	...	51.27
Delhi, India,	28 37	802	23.51	...
Mean { All places of observation			70.28	77.89
Mean { except Port Louis, Khatmandu, and Delhi,			76.19	80.51
Probable mean value in round numbers, Plains and Mountains together,				74.00

2. New World.

Place of Observation.	Latitude.	Plains. Amount in English inches.
San Luis de Maranhao, Brazil,	2° 29′ S.	276.12
Cayenne, Guayana,	4 56 N.	116.27
Paramaribo, Guayana,	5 40	229.39
Demerara, Guayana,	6 48	156.71
Cumana, Venezuela,	10 27	7.52
Trinidad,	10 40	62.92
Curaçao,	12 15	24.64
Granada, Little Antilles,	12 15	103.41
Barbadoes, Little Antilles,	13 05	57.58
Kingston, St Vincent, Little Antilles,	13 10	82.07
St Vincent, 9 miles east of Kingston,	13 19	67.13
Guadeloupe, { Basseterre,	16 05	126.85
Guadeloupe, { Matouba,	...	292.63
Antigua, Little Antilles,	17 03	39.49
Jamaica, mean of the whole Island,	18 00	49.12
St Bernards, Tortola Virgin Isles, 926 feet high,	18 20	65.06
Tivoli, Haiti,	19 00	106.68
Vera Cruz, east coast of Mexico,	19 11	66.09
Cape Haitien, Haiti, or S. Domingo,	19 43	127.88
Rio Janeiro, Brazil,	22 54 S.	58.88
Havana, Cuba,	23 09 N.	90.66
Mean { All places of observation		104.20
Mean { except Cumana and Curaçao,		113.49
Probable mean value in round numbers,		113.00

Mean Yearly Amount under the Tropics, Old and New World taken together, = 93 inches.

II.—YEARLY AMOUNT OF RAIN IN THE TEMPERATE ZONE.

1. Europe.

District or Country.	Yearly Amount of Rain, in Eng. inches.	Division in the different Seasons.—Per centage of Rain in			
		Winter.	Spring.	Summer.	Autumn.
Madeira,	29.82	48	17	4	31
South-west coast of the Spanish Peninsula,	30.57	32	29	4	35
Sicily,	23.55	39	15	4	32
West side of the Appennines,	55.17	27	23	12	38
East side of the Appennines,	26.70	26	25	17	32
South declivity of the Northern Appennines,	63.96	27	23	13	37
Transpadanic Plain,	25.61	26	24	16	34
Cisalpanic Plain,	36.25	21	23	25	31
South declivity of the Alps,	57.57	20	22	26	32
North side of the Alps,	35.27	19	26	25	28
West declivity of the Alps,	46.92	20	24	16	40
Valley of the Rhone,	35.18	20	23	20	37
South France,	23.54	25	23	13	39
West France,	24.61	26	21	22	31
North France and Belgium,	23.47	21	24	29	26
Middle Rhine Valley,	23.62	18	24	31	26
South Germany,	26.64	18	21	37	24
Hungarian Plains,	17.66	19	25	26	29
Middle and North Germany,	20.35	20	23	27	29
Netherlands,	26.70	20	18	30	32
British Islands, Plains,	24.51	23	20	27	30
British Islands, Mountain Ranges,	40.59	26	19	25	30
South Scandinavia and West Russia,	21.93	19	17	33	31
West coast of Scandinavia,	82.12	26	18	21	35

Mean quantity of rain in Europe between 36° and 60° north latitude, 34 inches.

Maximum,	{ Coimbra, in Portugal, mean of two years' observations,	224 inches.
	{ Tolmezzo, in the Southern Alps, mean of twenty-two years' observations,	85 "
	{ Bergen, in Norway, ten years' observations,	82 "
Minimum,	{ Inkaterinburg,	13 "
	{ Madrid—Table-land of New Castile,	9 "

2. America.

Places and Districts.	Latitude.	Amount of Rain, in Eng. inches.
Key West, in Florida,	24° 33 N.	35.09
Charlestown, in South Carolina,	32 43	47.60
Washington, Capital of the United States,	38 53	36.30
Marietta, in the State of Ohio,	39 25	34.16
West Chester, in Philadelphia,	39 58	46.89
Providence, in Rhode Island,	41 49	41.64
Cambridge, in Massachusetts,	42 25	38.42
Burlington, in Vermont,	44 28	39.44
East Port, in Maine,	44 54	36.28
New York mean of four years' observations in 32 places,	41 43	36.28

Mean Quantity of Rain in the United States of North America, between 24½° and 45° north latitude, ... 39 inches.

3. Australia.

Places and Districts.	Yearly Amount of Rain, in Eng. inches.	Division in the different Seasons.—Per centage of Rain in			
		Winter.	Spring.	Summer.	Autumn.
Parramatta, New South Wales,	28.78	0	14	38	48
Sydney, New South Wales	26.68	18	23	24	35
Habartown, Van Diemen's Land,	22.42	22	35	25	18
Albany,	22.06	60	20	3	17
South Australia,	23.43	...	...	...	...

Probable mean quantity in Australia, from 33° to 43° south latitude, = 26 inches.

Average value of the amount of rain.

Within the tropics,	93 inches.
In the temperate zone of the Northern Hemisphere,	37 "
In the temperate zone of the Southern Hemisphere,	26 "

[1] At Malta, the usual direction of the wind is north 3° east, while in winter, south winds commonly prevail.

[2] "During a great portion of the year the serene atmosphere loses its transparency, becomes troubled, and is covered by a singular vapour, known to the inhabitants under the name of the *garua*, *camanchaca*, or *garuma*." These vapours "are so thick, that the sun rays through them with the naked eye assume the appearance of the moon's disc. They commence in the morning, and extend over the plains in the form of refreshing fogs, which dissipate soon after mid-day, and are followed by heavy dews, which are precipitated during the night."—*Professor Fraser, Annales de Chimie et de Physique, quoted in Edinburgh New Philosophical Journal, January, 1819.*

[3] As in the tropics (e.g., in the Antilles), so in Caracas, the fall of hailstones creates astonishment equal to that caused by the fall of aerolites such as, and in Lima the remembrance of the days are kept up to which a peal of thunder was heard, as the 13th July 1652, 6th, another in 1720, and 1747, and the 18th of April 1802.—*Humboldt.*

HYETOGRAPHIC,

OR

RAIN MAP OF EUROPE.

CONSTRUCTED FROM THE HYGROMETRICAL OBSERVATIONS OF THE LAST CENTURY.

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I. GENERAL LAWS AFFECTING THE DISTRIBUTION OF RAIN IN EUROPE.

Europe affords many examples of the climatological positions explained in the introductory notes to the preceding chart of this division. These we shall notice in the order therein adopted.

1. The amount of rain decreases as we recede from the equator towards the poles; thus, while under the tropics the yearly average amount of rain is 85 inches, in Italy it is less than one-half, or 45 inches; in England about one-third, or 30 inches; in the north of Germany about one-fourth, or 22½ inches; and at St Petersburg, only one-fifth, or 17 inches.

2. The quantity of rain decreases, in general, in ascending from low plains to elevated table-lands; but this law is reversed in ascending steep and rugged mountain chains. The former case is illustrated by the Iberian Peninsula; for while on the coasts of Spain and Portugal the annual fall of rain amounts to from 25 to 35 inches, on the plateau or table-land of Castile, which is surrounded with mountains, it is only 10 inches. In the latter case, the effect of the Alps is so great, that while the annual amount of rain in the Valley of the Middle Rhine and on the Plateau of Bavaria is only 21 inches, in Berne and Tegernsee, at the foot of the Alps, it is nearly double, or 43 inches.

In England the amount of rain which falls in the mountainous districts is more than double that of the less elevated portions of the country; thus, while the meteorological reports for Essex give only an annual average of 19.5 inches, those for Keswick in Cumberland show no less than 67.5; and at Kinfauns in Scotland, the amount shown on an average of five years, is 25.66, whilst that in the vicinity, placed on a hill 600 feet above the level of the sea, amounts to 41.49 inches.

3. The amount of rain decreases in the direction from the coasts to the interior of continents, and this is exemplified by the difference between the coasts of the Atlantic Ocean and the countries of Eastern Russia. The western coasts of Great Britain, France, and Portugal, have an annual average of from 30 to 35 inches, Bergen in Norway has 89, and Coimbra in Portugal 111 inches of rain; while in Central and Eastern Europe, in Moravia, and through Poland and Russia, it falls to 15 inches. At Iekaterinburg on the Ural Mountains it is only 13 inches; and in the interior of Siberia it is still less.

4. In both hemispheres within the temperate zone, the western coasts are proportionally more moist than the eastern. In this quarter of the globe the difference is explained by the prevalence of the westerly winds, which, before arriving in Europe, become charged with vapour in passing over the Atlantic Ocean; whilst those which blow from the east pass over the interior of the continents of Europe and Asia, where the dryness of the air increases so rapidly from west to east, that a mean of seven years' observations gives to Moscow two hundred and five, to Kazan ninety, and to Irkoutsk only fifty-seven days of rain;[1] and the rains which accompany the westerly winds have been observed at Penzance to exceed those caused by the easterly winds, in the ratio of about 3 to 1. The determining causes of the distribution of rain in Europe are thus seen to be the predominance of westerly winds, with the existence of a vast ocean on one side, and a great continent on the other. The former of these causes is thus explained by A. von Humboldt: "The predominating winds of Europe are westerly, which, for the western and central portions of it, are sea winds—currents which have been in contact with a mass of waters the temperature of which, at the surface, even in the month of January, does not, at the 45° and 50° of latitude, fall below 51° and 48° Fahrenheit."[2]

5. Observation shows that in different regions of the globe it rains more at one season than at another; now if, in a certain district, during one of the four quarters of the year, a third part of the annual quantity of rain falls, while the remaining two-thirds is either equally or unequally divided over the other three periods, we can make this trisection available as a scale for characterizing the hystographic condition of the countries, and say the period of the year in which that third falls to the earth is the rainy season of the district under consideration.

Measuring the quantity of rain in Europe by this scale, we find that it is divided into the three following rain provinces:—

1*st*, The province of the winter rains, comprehending part of the southern portions of Europe;

2*d*, The province of the autumn rains, comprising the remainder of the southern and the western portions; and,

3*d*, The province of the summer rains, embracing the whole of the interior of the Continent.

The limits of these provinces are indicated by colours on the map, and the method of their delineation is explained on the next page; but it is obvious that in this, the first attempt to give a survey of the proportions of rain in Europe, these can only be considered as an approximation to the truth. Generally, a strict line of separation can scarcely be possible, where the transition from one province to another is gradual.

II. NUMBER OF RAINY DAYS IN THE COURSE OF A YEAR.

In considering this question, with reference to the countries of Europe, we find, that in the province of the winter rains, and in that part of the province of the autumn rains near the Mediterranean, there are comparatively few rainy days in the year. At the Strait of Gibraltar, the number is sixty-eight, and in the north of Syria fifty-four days. The number increases towards the north. In the south of France it is seventy-six, in the peninsula of the Apennines eighty-nine, in the plains of Lombardy ninety-six, and in Hungary it amounts to one hundred and twelve. The quantity of rain which falls on each rainy day within this whole space amounts, on an average, to 4½ inches, with the exception of Hungary, where it amounts to only 1⅞ inch. In the northern part of the province of the autumn rains, in the vicinity of the Atlantic Ocean, as well as in the interior part of the province of the summer rains, the number of rainy days in a year is very considerable; in general this number is greatest near the sea, and decreases in proportion the farther we penetrate into the interior of the province of the summer rains. On the eastern side of Ireland it rains on two hundred and eight days; in the Netherlands on one hundred and seventy; in England, France, and the north of Germany, and on the Gulf of Finland, on from one hundred and fifty-two to one hundred and fifty-five days; on the plateau of Germany on one hundred and thirty-one; and in Poland on one hundred and fifty-eight days; while on the plains of the Volga at Kazan, it rains on ninety, and in the interior of Siberia, only on sixty days. The amount of precipitation on a rainy day, within the western part of this district is nearly uniform, and varies between 1¼ and 2½ inches. This decrease in the amount of rain, and the number of rainy days in proceeding from the west to the east of Europe and the north of Asia, is owing, as already observed, to the direction of the rain winds, which, in the northern part of the autumn, and the greater part of the summer provinces is westerly. These winds carry the vapours which are accumulated on the Atlantic Ocean to be precipitated over the continent, and as they lose the moisture with which they are charged in traversing the land, the amount of precipitation decreases in proportion as the clouds travel in an easterly direction. Referring to Europe north of the Alps and Pyrenees, M. Kämtz says: If the north-east wind always prevailed it would never rain; for it passes over lands, before arriving at the low latitudes, where the elevation of temperature removes the vapours from the point of condensation. On the contrary, if the south-west wind were to blow incessantly, it would always rain; for as soon as the moist air cools the vapour of water is precipitated.

One point of view, not hitherto sufficiently adverted to, by which we may judge of the proportions of rain, is, the number of days on which rain falls. It appears from the map, that the number of rainy days is greatest in Ireland and in the Netherlands, and that there is a gradual decrease thence, as well in an easterly direction towards the interior of the Continent, as southward to the countries on the coasts of the Mediterranean Sea. In Western Europe, it rains on twice as many days as in Eastern Europe, along the course of the Volga; in Ireland, on three times as many days as in Italy and the south of Spain.

III. NUMBER OF DAYS ON WHICH SNOW FALLS IN EUROPE.

The number of days on which snow falls in Europe increases in the following order from south to north: Palmero has two and a-half snowy days in each winter, Rome one and a-half, Florence one and one-third, Nice under a-half, Venice five and a-half, Milan ten, Paris twelve, Carlsruhe twenty-six, Copenhagen thirty, and St Petersburg one hundred and seventy-one. Meteorological observations are very defective in distinguishing the quantity of water which falls in the form of rain from that which falls in the form of snow, and the same may be said regarding the distinction between the number of rain and snow days. In St Petersburg the quantity of rain, compared to that of snow, is as 1,000 to 384. The first snow falls about the 6th October, and the last about the 17th April.

According to twenty years' observations, it appears that snow may occur in Palermo from December to April. In Florence it occurs even in October, and in Rome it has occurred in April.

In the valleys of Southern Europe, where, as in Rome and Palermo, the mean temperature of the three winter months amounts to 47° and 52°, it is evident that there cannot be either snow or ice of any consequence, or of any long duration, since it must be quickly melted under the influence of the sunbeams.

Nevertheless, during the severe winter of 1812, when Napoleon's army was destroyed in the snow fields of Russia, the sheet of water in the Villa Borghese was so strongly frozen, that the Romans were enabled to enjoy the rare pleasure of skating for several days together. In the Campagna di Roma, as has been said, snow very seldom falls; when that does happen, however, the country people fly into the city, as before the plague, and the Government distributes provisions amongst them. Snow is still more rare in the Pontine Marshes; while the Monte Cavo, the Soracte, the Gennaro, and Corsuna, which have a mean elevation of 2,344 to 3,197 feet, remain long visible from Rome, covered with snow. On the high chain of the Apennines, the snow lies longer; and in the beginning of February 1839, the passage between Matilica and Fossato, over the ice-covered road, was not without danger. The snow on the Terminillo Grande, in latitude 42° 30', first melts in the month of June. The equatorial limit of the fall of snow is indicated on the map. The whole continent of Europe lies, according to this, within the snow line. However, this limit is only to be considered as an approximation. At Lisbon, in the vicinity of this line, there were, during fifteen years, four winters in which it snowed (1806, 1811, 1814, 1815); on the coast of Algarve, this phenomenon is almost unknown.[3] Before 1756, it was said that snow had never been seen in Sevilla; in that year, however, the whole neighbourhood was covered with it.[4] In Gibraltar, snow is rare; and ice is never seen thicker than a Spanish dollar.[5] Malta is never visited by snow flakes.

IV. RAIN WINDS IN EUROPE.

It is an important point in hyetographic inquiries, to ascertain the direction of the prevailing winds which usually bring rain. These, in so far as they are yet known, are represented by arrows on the map. In Western Europe, as well as in the interior of the Continent to near Moscow, the south-western currents of air form the rain-wind; that is to say, it rains most frequently during that wind, and most rarely during the opposite or north-east wind. In the north of Europe, the very opposite is found to be the case, for there the north-east is the rainy wind; and on the southern border of the Spanish Peninsula, the heaviest winter rains occur during the south-west winds.

[1] Bulletin de la Soc. de Moscow 1837, No. iv., p. 92.—*Humboldt, Asie Centrale*, iii., p. 69.

[2] Asie Centrale, tom. iii., p. 78.

[3] Balbi, Essai Statistique, du Royaume de Portugal, tom. i., p. 87.

[4] Lampadius, Systematischer Grundriss der Atmosphärologie, s. 279.

[5] Montgomery Martin, British Colonies, vol. v., p. 60.

HYETOGRAPHIC OR RAIN MAP OF EUROPE

From the DRAWINGS OF PROFESSOR BERGHAUS, Berlin.

BY A.K. JOHNSTON, F.R.G.S.

EXPLANATION.

The amount of Precipitation is indicated by shading which is darker in proportion as the quantity of Rain is greater.

10 ..... X ..... XX ..... &c. Isohyetoses or lines of equal annual amount of Rain, extending from 10 to 100 Inches. These lines unite all the places in Europe having the same annual amount of Rain.

(5) ..... Isothermobrose or Curves of the distribution of Summer Rain. Each point expresses 5 Pt Cent of the annual amount of Rain. thus 5 Pt Cent is indicated by 1 point 10 by 2 points &c.

R.D. 112 Sec. Rainy days within a year. S.D. 171 Sec. number of days on which Snow falls within a year. The figures placed after the number of rainy days, thus, 114 &c. indicate the amount of rain during each rainy day in hundredth parts of an inch. ——→ Direction of Rain Winds.

The Map is constructed to a scale of French Inches, 15 of which are equal to about 16 English Inches, so that one fifteenth part added to any number on the Map will give English Inches very nearly. Thus the 30 on the W. Coast of Ireland would be 32 English Inches.

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

V. EXPLANATION OF THE MAP.

The accompanying map is an attempt graphically to represent the proportions of rain in Europe. Rain falls in drops varying in size from about one-twenty-fifth to one-third of an inch, and the quantity is measured by the depth which falls on the surface of a square foot, determined by inches and parts. The map is constructed on the scale of French inches, fifteen of which are equal to sixteen English inches, nearly. In the following remarks the English equivalent of the French figures is given in foot-notes below. The principle on which this map is constructed is the same as that adopted for the Rain Map of the World—that is to say, the amount of rain is indicated by shading, which is darker in proportion as the quantity is greater; but besides the comparative amount of rain in the different countries, this map shows, by means of curved lines, the amount of rain in the different seasons, and the annual per centage of summer rain in Europe. The points which have equal quantities of rain are united by interrupted lines, on the physico-graphic principle, adopted by A. von Humboldt to represent the distribution of heat. These lines may be denominated isohyetoses (or lines of equal rain-fall); they constitute a series of curves, which express an amount of rain increasing from 10 to 100 inches, a curve being added for every 5 inches of additional quantity. These isohyetoses limit certain regions, the shading of which is darker in proportion as the quantity of rain is greater. We find from the map that the darkest places, or those on which the greatest quantity of rain falls, are situated on the west coast of Great Britain and Ireland, the coast of Scandinavia, the Eastern Alps, and in the centre of Portugal. The shading of the countries is lighter in proportion as they recede from the coasts and the mountains, on the principle explained in the introductory notes.

1. Proportions of Rain.—If we assume the yearly quantity of rain as unity, or suppose it = 100, then the atmospheric water falling in every period of the year will form aliquot parts or per centages of the annual amount.

These proportions may be graphically constructed, as is done in the case of the summer rains in our map, so that the quantity is rendered perceptible by means of curves called isothermobroses (or lines of equal summer rain), which show the amount from 0 to 50 per cent. of annual rains, and in an ascending scale from 5 to 50 per cent.

The curve or isothermobrose of 0—that is, the line in the vicinity of which it never rains in summer—passes through the eastern part of the Mediterranean Sea, as well as through Syria, and does not touch Europe. The curve or isothermobrose of 5 per cent. annual quantity of rain, first touches our quarter of the earth, still only in a small portion of its southern countries, namely, to the north of Greece, the south of Italy, the south-western section of Spain, and the southern half of Portugal. If we follow the course of these isothermobroses further, we find that they run pretty nearly parallel with the general contour of the coast of Europe, so that the curve of 20 per cent. of summer rain will be found as well in the north of Europe—on the Scandinavian coast—as in Dalmatia in the south. The curve of 15 inches yearly quantity of rain lies entirely in the interior of the Continent; and this seems to be the medium amount of atmospheric precipitation in the whole of Eastern Europe; for, on the borders of Asia, at Slatoust and Iekaterinburg, in the Ural Mountains, the annual amount of rain probably does not exceed 14.3" and 12.10;[1] and the curve or isohyetose of 10 inches lies, it is conjectured, beyond Tobolsk, while it cuts the course of the River Irtish somewhere about 72° east longitude.

The isohyetoses, or curves from 20 to 35 inches medium quantity of rain, which touch upon Great Britain and Ireland, as well as the Netherlands and the west coast of France, are, in so far as their continuation in the Atlantic Ocean is concerned, naturally to be considered as conjectural; and this prolongation, therefore, is only given to represent the probable connection of the phenomena.

The isothermobroses of 45 and 50 per cent. appear on the limits of Asia—the former cuts the Ural Mountains, at Slatoust; the latter at Iekaterinburg.

These last named determinations are, however, only to be considered as an approximation to the truth; because they rest on a single year's observations, although they are corrected by the mean of many years' corresponding observations in St Petersburg.[2]

2. Rain Provinces.—The province of the *winter rains* is coloured blue on the map. The line of limit between this and the province of the autumn rains touches the east coast of Italy, nearly under latitude 43°—extends thence probably over the crest of the Apennines southwards—leaves these beyond the parallel of Naples, perhaps under latitude 40°—proceeds for a time along the west coast of Calabria—passes north of the coast of Sicily—extends thence to the Island of Sardinia, so as probably to cut it near its southern shores—strikes the Spanish coast probably at the *Cabo de la Nao*, opposite the Island of Iviça, and leaves the Iberian Peninsula between Lisbon and Coimbra. All the countries to the north-west of this line of separation belong to the province of the autumn rains, and all south to that of the winter rains. The province of the *autumn rains* is coloured orange tint, and the line of separation between it and the province of the *summer rains* (coloured green), proceeds west from the Carpathian Mountains, to the north of the Alps, through the middle of France, the west of Holland, and by the northern part of the Gulf of Bothnia, through the White Sea to the Arctic Ocean.

3. Number of Days of Rain and Snow.—The number of days on which it rains in any particular region, and the amount of rain or snow which falls on each rainy day, are indicated by letters and figures on the map. Thus, for example, the signs n. n. 112 in Hungary, indicate that in this country (in the plains, for which alone, and, indeed, only for Buda or Ofen, observations exist) it rains on one hundred and twelve days during the whole year, and that on each of these rainy days the quantity which falls amounts to 0. 14.' The quantity of rain which falls on a rainy day is greater in the south than in the north of Europe; in the south of Spain it is twice as great as in England; in Italy, three times as great as in Ireland. In Gibraltar the number of rainy days is only sixty-eight, while the amount of precipitation is forty-three inches; the quantity of rain which falls in it, therefore, exceeds by three times the daily quantity in Ofen and St Petersburg. The number of days on which snow falls in the course of a year is expressed in figures placed after the letter s. Thus at Rome, the sign s. 1½, and at St Petersburg the sign s. 171, indicate that at these two places the average number of days on which snow falls in the year is one and a-half, and one hundred and seventy-one respectively.

4. Comparative Quantity of Rain in different parts of Europe.—That portion of Europe in which the greatest quantity of rain falls, is very probably Coimbra and its environs. Coimbra, in the Valley of the Mondego, lies at the western declivity of the Serra Estrella, which is remarkable, as well on account of the height of the mountains (7,500 feet) as for the serrated formation of their summits. Unfortunately, the observations employed for this place embrace a period of only two years (1816–17), so that their mean value cannot warrant any great certainty, in elements which, like the quantity of rain, present such great fluctuations from one year to another; besides, it is uncertain whether they are not disfigured by mis-prints.[4]

If we take them exactly as they are presented to us, they give a quantity of rain equal to 211 inches[5]—an enormous amount, which reminds us of the heaviest torrents of the tropics.

The quantity is divided over the periods of the year as follows: Winter, 23.5;' Spring, 20.9½;' Summer, 19.8;' Autumn, 147.2½ inches.[6] On account of the uncertainty referred to,[7] Schouw has excluded from the calculation of observations the months of September and October of the above-mentioned years, and thus determines the annual quantity of rain at Coimbra to be 127" inches.[8]

Kämtz has gone still further, and, besides these two months, has left out of view the month of November 1817, whereby he brings out a yearly quantity of 111¼" inches.[9]

Notwithstanding its high latitude, the coast of Norway is distinguished by an extraordinary abundance of rain, which, according to observations made at Bergen, amounts to 77⅞,[10] or even to 83"[11] inches.[12] This quantity of rain and snow, immense for a climate situated in 60° north latitude, is caused by the high Scandinavian mountain chains, which prevent the passage of the clouds blown from the Atlantic Ocean; they are, therefore, deposited on the summits of these mountains, and discharge themselves on the western declivities, and into the valleys, throughout the year, but chiefly during autumn and winter. The third region in Europe where most rain falls, is the Valley of the Upper Tagliamento, in the Eastern Alps. Here, at the height of 1,000 feet above the level of the sea, lies the little town of Tolmezzo, where observations on the quantity of rain have been made during a period of twenty-five years. These give a yearly average of 90 inches[13]—in the year 1807 it amounted to 151 4-8 inches[14]—and hence it is not improbable, that in the higher regions of those Alpine districts the mean annual quantity amounts to 100 inches.[15]

5. Rain Winds.—The direction of the winds, which usually bring rain, is indicated by arrows on different parts of the map, the head of the arrow marking the point towards which the wind blows.

[1] 16.1 English inches. [2] Recueil d'Observations Magnétiques et Météorologiques faites dans l'Etendue de l'Empire de Russie. Annee 1837. This year gives the amount of summer rain for Slatoust, 50 inches. In Iekaterinburg, 63 per cent. of the yearly amount. The correction is, 13 per cent.

[4] 0.15 inch, or about one-seventh of an English inch.
[5] Balbi, Essai Statistique sur le Royaume de Portugal et d'Algarve, tab. 14, p. 112.
[6] 223 inches. [7] 22 inches. [8] 21.2 inches. [9] 137 inches.
[10] Balbi also brings forward the supposed circumstance, that the autumn of 1817 was very rainy; but this was not the case, at least the Diary of Lisbon shows no trace of it.
[11] 135.7 inches. [12] Climat de l'Italie, tom. i., pp. 160, 169.
[13] 119 inches. [14] Lehrbuch der Meteorologie, bd. i., s. 432. [15] 80½ inches. [16] 83.6 inches.
[17] The first account is, according to Schouw's reckoning, Climat de l'Italie, tom. i., pp. 171, 184; the second according to Kämtz, who makes use of some additional observations, Lehrbuch der Meteorol., b. i., s. 465.
[18] 98 inches. [19] 151¼ inches. [20] 109½ inches.

ON THE POLARIZATION OF THE ATMOSPHERE.

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INTRODUCTION.

When the light of the sun or of any self-luminous body has been transmitted through certain crystallized substances, or has been reflected from, or refracted by, bodies not metallic, it suffers a physical change, to which the name of *plane polarization* has been given. This physical change consists in decomposing common light into two equal portions of polarized light, one of which is polarized in a plane at right angles to that in which the other is polarized. In doubly refracting crystals, the two pencils are polarized in opposite or rectangular planes; and when common light is reflected from any body not metallic, whether it is solid, or fluid, or gaseous, a portion of the incident light enters the body; and of the portions thus reflected and refracted, precisely the same quantity is polarized—the light polarized by refraction being polarized in a plane at right angles to that which is polarized by reflection.

If the earth had no atmosphere the sky would appear absolutely black; and when the sun sets we should be left in utter darkness. The existence of twilight, however, the blue colour of the sky, and the refraction of the rays which emanate from the stars and planets, place it beyond a doubt that the pure air in which we live and breathe, is capable of acting upon light like all other bodies, and consequently, of producing that physical change which constitutes *polarization*. The polarization of the blue sky, or of the atmosphere, was, therefore, observed and studied by different philosophers, both in France and England; and it was speedily ascertained, in conformity with the laws of polarization, that the polarization was a *minimum* in the vicinity of the sun, where his light is reflected at angles approaching to 90°, or where the incident and reflected rays form an angle approaching to 180°; that it was also a minimum in the region opposite the sun, where his light is reflected at an angle approaching to 0°, or at a perpendicular incidence; and that it was a *maximum* in those intermediate parts of the sky, which are distant about 90° from the sun, and where his light is reflected at an angle of about 45°, the polarizing angle for *Air*.

Such was the first view which was naturally taken of the polarization of the atmosphere, and a considerable time elapsed before its leading elements were determined, and its more important phenomena observed and measured. It is to M. Arago, to whom this branch of science owes such deep obligations, that we are indebted for the discovery of the first and leading fact on which the law of atmospheric polarization depends. In examining the region of the sky opposite to the sun, he discovered *a neutral point*, or a point in which there is *no polarization* whatever. This neutral point he found to be 25° or 30° above the point diametrically opposite to the sun, or what we may call the *antisolar point*; and we shall distinguish this pole of no-polarization by the name of *M. Arago's neutral point*, or the *antisolar neutral point*. It is best seen after sunset.

In the year 1840, M. Babinet discovered a second neutral point, situated about the same distance above the sun as the neutral point of M. Arago is situated above the antisolar point. This point is most distinctly seen immediately after sunset, but is generally much fainter than the other, owing to the discoloration of the blue sky by the yellow light of the setting sun.

Our readers are no doubt aware, that when light is reflected from the surfaces of transparent bodies, a certain portion of it, and at a particular angle the whole of it, is *polarized* in the plane of reflection, or *positively*; while precisely the same quantity of the transmitted light is *polarized* in a plane at right angles to the plane of reflection or refraction, or *negatively*.[1] Now, in the part of the sky between the neutral point of M. Arago and that of M. Babinet, the light was polarized *positively*; while in the parts of the sky between the first of these neutral points and the antisolar point, or between the second and the sun, it was polarized *negatively*. Hence, it became obvious, that the two neutral points must be produced by a compensation, in which light polarized *negatively* neutralized light polarized *positively*, and that the *negative* light was either produced by *reflection* in a plane at right angles to that passing through the sun, the neutral point, and the observer, or by *refraction* in a plane passing through these three points, or by both these causes combined. But in whatever way the *negative* polarization was produced, it was manifest that the same cause ought to produce a *neutral point beneath the sun*. After many fruitless attempts to discover this neutral point—owing chiefly to the predominance of the sun's light at the part of the sky where it should be found—I at last observed, under a very favourable state of the atmosphere, that the polarization of the sky was *negative* in the space between the risen sun and the horizon. This observation placed it beyond a doubt, that there must be a neutral point below the sun, where that *negative* polarization passed into *positive* polarization; and by concealing the sun from view, and admitting no light to the eye but what came from the probable place of the neutral point, I succeeded in discovering it. After communicating this discovery to M. Babinet,[2] early in 1843, he made several ineffectual attempts to confirm it; and it was not till the 23d July 1846, when the state of the sky was peculiarly favourable for the observation, that he succeeded in obtaining a distinct view of it.[3]

Before proceeding to explain the map of the lines of equal polarization in the pure blue sky, I shall give a brief account of my observations on the three neutral points to which we have referred:—

I.—ON M. ARAGO'S NEUTRAL POINT.

This neutral point is marked P in Fig. 2 of the map. In the normal state of the lines of equal polarization, as shown in the map, namely, when the sun is in the horizon, this neutral point is about 18½° above the horizon or about 25° from the antisolar point. When the sun is about 11° or 12° above the horizon, and the antisolar point of course as much below it, the neutral point is in the horizon, and, consequently, only 11° or 12° above the antisolar point. As the sun descends to the horizon, and the antisolar point rises, the distance of the neutral point from the latter gradually increases; and when the sun reaches the horizon, the neutral point is 18½° above it, and therefore 18½° distant from the antisolar point. After the sun has set, the distance of the neutral point from the antisolar point increases; that is, it rises faster than the sun descends, and its maximum distance when the twilight is very faint, is about 25°.

In the latitude of St. Andrews, M. Arago's neutral point is above the horizon all the day between the middle of November and the end of January. In the other months of the year, it never rises till the sun is within 11° or 12° of the horizon, and never sets till the sun is 11° or 12° above the horizon.

II.—ON A SECONDARY NEUTRAL POINT ACCOMPANYING M. ARAGO'S NEUTRAL POINT.

I observed the first traces of this remarkable phenomenon on the 8th of June, 1841, at 5h 50′, when the positive polarization was strongest close to the horizon, whether land or sea, and to about 1½° above it. Hence, when M. Arago's neutral point rose, it *did not appear first in the horizon*, but about 1½° above it, the compensation taking place where the positive polarization was weaker than in the horizon. When this took place, we had the singular phenomenon of a neutral point *with positive polarization* on each side of it. When this phenomenon was more fully developed, under a favourable state of the horizon, the positive polarization was overcome by the advancing negative polarization. The negative polarization was then immediately below the ascending neutral point; but at a certain distance, a few degrees below the neutral point, the negative polarization was compensated by the excess of positive polarization close to the horizon, and the beautiful phenomenon was seen of two neutral points separated by bands of negative polarization. This phenomenon was best seen on the sea horizon, which was marked by an obscure band a few degrees high, that indicated the existence of a distant haze. On the 21st April, 1842, I observed the secondary neutral point under favourable circumstances. At 6h 22′, when the *primary* neutral point was 15° high, the *secondary* one was 2° 30′ high. At 7h positive bands were still seen above the sea line, and were strongest upon the obscure band above the visible sea line.

III.—ON M. BABINET'S NEUTRAL POINT.

This neutral point, marked P in Figs. 1 and 2 of the map, is situated about 18° 30′ above the sun, when he is rising or setting in a very clear sky. It is not so easily seen as that of M. Arago, and was therefore longer in being discovered. It is above the horizon during the greater part of the year in great latitudes, and being above the sun, it is of course always visible, when the sun is above the horizon in a clear sky. When the sun is in the zenith, this neutral point coincides with the sun's centre. As the sun's altitude diminishes, it separates from the sun's centre, its distance gradually increasing till it becomes 18° 30′, when the sun's altitude is nothing, or at sunrise and sunset.

The neutral point of M. Babinet must, like that of M. Arago, be accompanied, in certain states of the horizontal sky, with a secondary neutral point; but I have never had an opportunity of observing M. Babinet's neutral point when it either rose above or set beneath the horizon, which, though not essential, is the most favourable for observing a secondary neutral point.

IV.—ON THE NEUTRAL POINT BELOW THE SUN.

This neutral point is, as we have previously noticed, much more difficult to be seen than that of M. Babinet. In November, December, and January, this neutral point cannot be seen in our latitude, unless when, early in November and late in January, a higher degree of polarization in the sky brings it above the horizon at noon.

As theory indicated the existence of this neutral point, I long sought for it in vain; but when I was assured of its existence by the discovery of negative polarization, which often extended from the sun to the horizon when the sun's altitude was 30°, I took such precautions for excluding all unnecessary light from the eye that I at last observed it near the horizon, with a small portion of positively polarized light beneath it. I afterwards observed it repeatedly when the sun had higher altitudes, and was able to measure its varying distance from that luminary. On the 18th February, 1842, at noon, when the sun's altitude was about 22°, I observed this neutral point in the most distinct manner, the polarized bands being negative below the sun, and positive near the horizon. Its distance from the sun, therefore, was about 15° or 16°. I afterwards obtained the following measures of its distance from the sun:—

		Distance of Neutral Point from the Sun.
1842, February 21,	12h. 59′.	15° 0′
„ April	3, 11 45.	13 0
„ „	6, 11 6.	12 0
„ „	8, 2 7.	16 0 estimated.

On the 20th April, in a very fine day, the wind being west and the barometer 30.02, I obtained the following measures:—

	Distance from Sun.
April 20, 12h. 10′.	11° 20′
12 37.	10 40
2 21.	12 0
3 43.	12 85

The maximum polarization of the sky at the time of these observations was equal to a Rotation of 25½°, about 4½° below the greatest maximum.

On the 26th April 1842, when the barometer was at 30.00, and not a cloud in the sky from morning till night,[4] I obtained the following measures:—

	Distance from Sun.
April 26, 11h. 1′.	12° 15′
11 46.	12 30
3 30.	14 85
3 33.	15 5
4 10.	17 45

At 10h 53′, the maximum polarization of the sky, or the Rotation, was 28½°, and at 11h. 46′, and 3h. 45′, it was 28½°.

On the 27th April, I observed a remarkable series of phenomena relative to this neutral point. The sky was singularly fine—the barometer at 30.04, and at 10h 41′ the maximum polarization of the sky 28½°, the greatest that I have observed. At 10h 45′, the distance of the neutral point from the sun was 12° 5′, and consequently about 33½° *above* the horizon. At 12h 12′, a fog came rapidly from the sea. The neutral point below the sun was driven beneath the horizon, and Babinet's neutral point rose almost to the zenith. At 1h 20′, the fog diminished. The neutral point below the sun reappeared near the horizon, oscillating up and down, through a space of 5° or 6°, as the fog became alternately denser or rarer.

When the sky is clear, the neutral point below the sun approaches to the sun as his altitude increases, and finally coincides with the sun's centre when he is in the zenith. Hence it follows, that

[1] These terms are used for the purpose of abbreviation. An account of the Laws of the Polarization of Light by Reflection and Refraction, will be found in my papers in the *Phil. Trans.* 1815, p. 125, and 1830, p. 63, 133.

[2] *Comptes Rendus des Séances de l'Académie des Sciences*, tom. xvii. p. 991-993, 1843, 17th Nov.

[3] *Comptes Rendus*, &c., 27 Juillet, 1846, tom. xxiii. p. 150, and 3 Août 1846, tom. xxiii. p. 223. "M. Brewster," says M. Babinet, "a sans doute été guidé dans sa recherche par des vues théoriques; autrement il ne paraît pas probable qu'il eut fait, par observation seul de la polarisation atmosphérique, la découverte remarquable de ce point neutre si difficile à reconnaître, et que, depuis lui l'avais plusieur fois tenté inutilement de retrouver."—*Ib.* p. 225.

[4] The lines in the spectrum were ill defined, from unequal refraction in the air.

MAP OF
THE
LINES OF EQUAL POLARIZATION
IN THE ATMOSPHERE

CONSTRUCTED BY

SIR DAVID BREWSTER, K.H. D.C.L. F.R.S. V.P.R.S. EDINR

CORRESPONDING MEMBER OF THE INSTITUTE OF FRANCE.

FROM FOUR YEARS OBSERVATIONS

FIG. 1

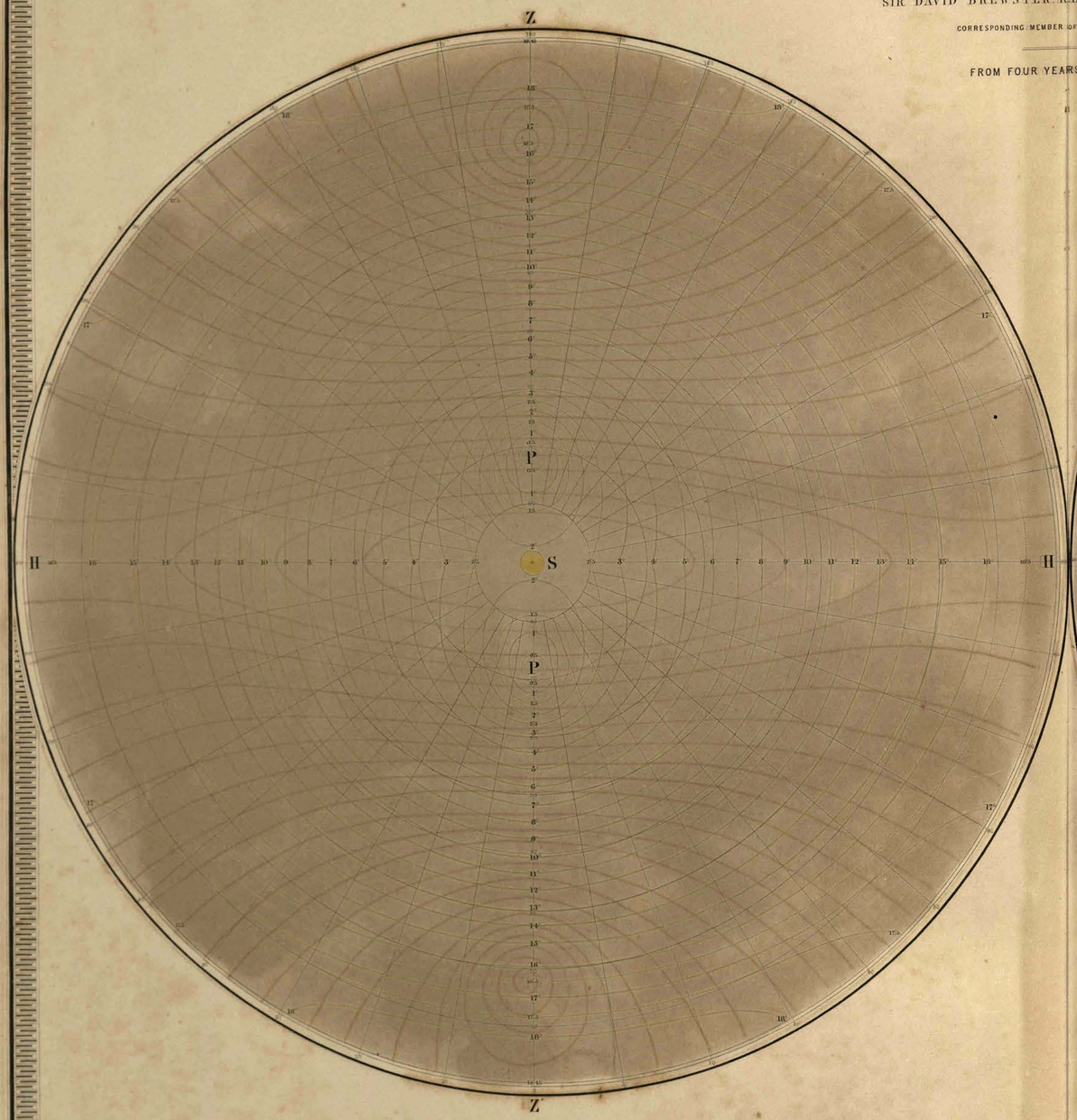
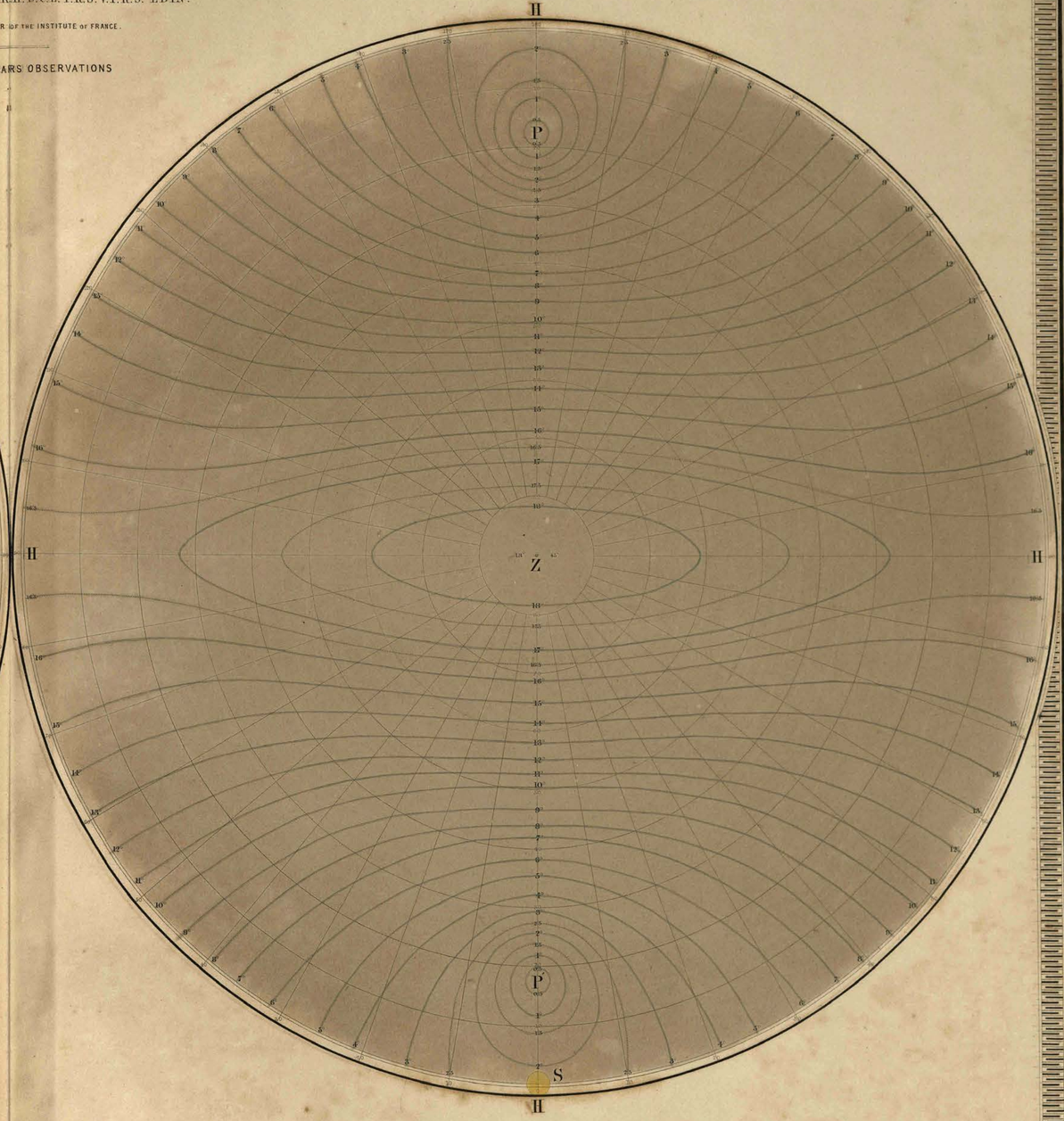


FIG. 2



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Engraved by W. & A.K. Johnston.

when the sun is in the zenith, the two neutral points in his vicinity meet in the sun, and the system of polarization lines becomes uniaxal.

Were the sky sufficiently clear, we should doubtless find a secondary neutral point accompanying the primary one below the sun; but in our climate, there is little chance of this phenomenon being distinctly observed.

In his observations on the antisolar *neutral point*, M. Arago observed, that it sometimes deviated from the plane passing through the antisolar point and the eye of the observer; and he justly ascribed this deviation to the influence of luminous clouds situated out of this plane. The same phenomenon takes place in reference to the other neutral points, though the deviation is, in these cases, less distinctly seen, from the interference of the sun's light. But it is not merely the position of the neutral point that is influenced by the intrusion of light different from that of the sky; the degree of polarization is always affected whenever we measure it in parts of the sky which have luminous clouds or illuminated terrestrial objects in their vicinity, or any luminosity in the field of view of the polarimeter. If the neutral point happens to be above or below any such object, its *distance* from the antisolar point or from the sun is increased or diminished.[1]

V.—ON THE MAXIMUM POLARIZATION OF THE SKY.

After having ascertained the position of the neutral points, or *Poles of no-polarization* as we may call them, the next most important element to be determined is the *Maximum polarization of the atmosphere*.

When a ray of common light is reflected from any transparent body, at an angle whose tangent is equal to the index of refraction, it is completely polarized; or when a ray of light, completely polarized in a plane inclined 45° to the plane of reflection, is reflected from any such body, its plane of polarization is brought into the plane of reflection; that is, *its plane is turned round* 45°. Hence complete polarization is measured by a rotation of 45°. When the polarized ray is reflected at angles above or *below* the angle of maximum polarization, its plane is less turned round, and its rotation is more or less than 45°, according as the angle of reflection is more or less distant from the angle of maximum or complete polarization.[2]

Different degrees of rotation below 45° may also be produced by the refraction of the polarized ray at one or more surfaces of glass,[3] the rotation increasing with the angle of incidence. Hence we may measure the *degree of polarization* wherever it exists, by observing at what angle of incidence it is compensated or neutralized, by reflection from a transparent surface, or by refraction at one or more such surfaces. I have found the last method the most convenient, and have therefore constructed a *polarimeter*, which measures the polarization of the sky, by observing with it either the varying angle at which it is compensated or neutralized by a fixed number of thin glass plates, or the varying number of refracting surfaces, by which the same effect may be produced at a fixed angle, capable also of being changed.[4]

With a *polarimeter* thus constructed, I have determined that the maximum polarization of a clear blue sky is equivalent to a rotation in the plane of a polarized ray of 30°; and that this maximum takes place at a distance of from 88° to 92° from the sun, and in the plane passing through the sun and the zenith. This maximum is of course dependent on the state of the atmosphere, both with respect to its magnitude and position; but we shall assume 30° as its amount, and 90° from the sun as its position in a normal state of the atmosphere, and when the sun is in the horizon.

VI.—ON THE FORM OF THE LINES OF EQUAL POLARIZATION IN THE ATMOSPHERE.

It is obvious, from the phenomena already described, that the polarization of the atmosphere, produced by the reflection of the sun's light from the matter, which composes the atmosphere, in planes passing through the sun, the point of reflection, and the eye of the observer, would have been equal in circles of which the sun and the antisolar point are the centre, had there been no disturbing causes, or had the atmosphere been a perfectly transparent medium. In this case the polarization would have been complete, or 45°; and this maximum would have occurred at a distance from the sun, the half of which was the polarizing angle of the medium. There is obviously, however, a cause depending on the zenith distance of the polarizing point of the sky, which acts in opposition to the polarization produced by reflection, and compensates for the neutral point already described. When the sun, therefore, is in the horizon, these two actions are rectangular, as in biaxal crystals; and we must, therefore, determine the form of the lines of equal polarization when the sun is in the horizon, and when the atmosphere is perfectly pure. When viewed, consequently, in their general aspect, the phenomena of atmospherical polarization may be represented by the formula—

$$R = 30^\circ (\text{Sin. D. Sin. } D')$$

Where R = Rotation, or degree of polarization, and
D and D′ = The distances of the point whose polarization is required from the *two* neutral points.

This formula would make the lines of equal polarization *Lemniscatæ*, as in biaxal crystals, and, consequently, the polarization in the horizon greater than in the zenith, which is contrary to observation. I have, therefore, added a correction, depending on the zenith distance and azimuth, which makes the formula coincide better with observation, namely:—

$$R = 33\tfrac{1}{3}^\circ (\text{Sin. D. Sin. } D') - 6^\circ\ 24' (\text{Sin. Z. Sin. A.});$$

Z being the zenith distance, and A the angle of azimuth.

Assuming, therefore, that the distance of the neutral points from the sun and from the antisolar point is 18° 30′, when the sun is in the horizon, that the atmosphere is perfectly pure and uniformly transparent, the lines of equal polarization will have the forms and the degrees of polarization represented by the formula. The direction of the polarization follows the same law as in biaxal crystals, the lines corresponding with the black hyperbolic branches in the polarized rings produced by these crystals, being distinctly seen with the polariscope.

VII.—ON THE CONSTRUCTION OF THE MAP OF THE LINES OF EQUAL POLARIZATION.

Had the map been on a greater or a less scale than it is, it might have been desirable to appropriate a single curve to every single degree, or to every two degrees of rotation or polarization. On the present scale, the curves would have been too numerous and close, had there been one to each degree; and with only one to each two degrees, they would have been too distant, in so far as that the form of the curves round the neutral points would not have been sufficiently seen. I therefore adopted such a number of curves, viz., 18½, as enabled me to get the curves, No. 2, continuous round each neutral point. Hence, the formula became—

$$N = 20^\circ\ 5' (\text{Sin. D. Sin. } D') - 3^\circ\ 9' \text{ Sin. Z. Sin. A,}$$

or in the plane passing through the sun and the zenith, in which Z and A become zero.

$N = 25^\circ\ 5'$ (Sin. D. Sin. D′)

In the zenith itself we have N = 18° 45′, and at P, P′, we have N = 0.

The curves thus obtained do not represent values of N in degrees of rotation, but in numbers, each of which is equal to 1°626. Hence R = N 1°626, and the distance between each curve is 1°626. The following table contains the Rotations or degrees of polarization, indicated by each of the curves numbered from ½ to 18.45 in the map:—

Values of N.	Corresponding degrees of Rotation, or Polarization, or values of R.
½	0°813
1	1 626
1½	2 439
2	3 252
2½	4 063
3	4 878
4	6 504
5	8 130
6	9 756
7	11 382
8	13 008
9	14 634
10	16 260
11	17 886
12	19 511
13	21 137
14	22 764
15	24 386
16	26 016
17	27 642
18	29 268
18.45	30 000

Hence the maximum polarization of the atmosphere, as measured by a Rotation of 30°, is equal to that produced by reflection from a plate of glass at an angle of 65½°, and with a refractive index of 1.48826, or to that produced by a surface of diamond at an angle of 75½°. The number of refractions at a given angle, or the angle, with a given number of plates of glass, at which a rotation of 30° is produced, will be found from the formula in my paper on the *Compensations of Polarized Light*.[5]

[1] On the 16th May 1842, barometer 30·3, the sun was faintly seen through a thick haze. At 5h 45′ A.M., the polarization was positive all the way from the sun to the horizon, so that the neutral point below the sun was below the horizon. Immediately afterwards, the sun was quite hid—a great glare supervened, and a *paraconcerous polarization* was observed, in which the polariscope gave no coloured bands.

On the 17th May, at 5h 30′, the sun's disc was quite white through a thick haze, and there was *no neutral point either above or opposite the sun*, the polarization being everywhere positive. When the haze is thicker on one side of the plane passing through the sun's spectrum, the neutral point deviates from that plane.

[2] See *Philosophical Transactions*, 1830, p. 69. [3] *Ib.* ibi., p. 137.

[4] See the *Transactions of the Royal Irish Academy*, vol. xix., part 2.

[5] *Transactions of the Royal Irish Academy*, vol. xix., part 2, p. 13.

EXPLANATION OF THE MAP.

The system of lines of equal polarization is represented in two separate projections. In Fig. 1, they are projected on a plane passing through the zenith of the observer, and perpendicular to the line joining the observer and the sun. The line HH is therefore the horizon; and HZH′ Z′ the plane passing through the zenith at right angles to the line joining the sun and the observer. The sun is represented rising or setting at S′, twice as large as it is; and the neutral points discovered by M. Babinet and myself, are shown at P, P′. The lines of equal polarization are coloured *yellow*, and the number of the curves, from 1 to 18, and the degree of rotation or polarization corresponding with each are marked upon them. The lower half of the figure supposed to be below the horizon, shows the system of curves in the atmosphere of our antipodes, to whom the sun is rising when he is setting with us, or setting when he is rising.

In Fig. 2, the system of curves of equal polarization is projected on the plane of the horizon HHHHH, the sun rising or setting at S, S′ being the antisolar point. The neutral point of M. Arago is shown at P, and that of M. Babinet at P′, the point being at Z.

As the sun *rises* above the horizon, the lines of equal polarization change their form, and the degree of polarization varies at points of the sky whose distance from the sun is invariable. The neutral points *above* and *below* the sun approach his disc till he reaches the meridian, when the distance of each from the sun is a *minimum*; they then separate again, and attain their maximum distance, when he reaches the horizon. In countries where the sun passes across the zenith, these two neutral points coincide with the sun, when he reaches the zenith, and again separate.

As the sun descends beneath the horizon, the neutral point of M. Arago separates from the antisolar point, and when this point is first seen in the morning before sun-rise, its distance from the antisolar point is a maximum; it gradually approaches that point till the sun rises, and also till the neutral point itself reaches the horizon, when its distance from the antisolar point is a *minimum*.

When the altitude of the sun is 45°, the distance x of the neutral point above the sun is about 13° 5′, and the distance x' of the neutral point below the sun 6° 42′; at other altitudes we have

$x = \Delta \cos A$, and
$x' = \Delta \cos A$,
Tang. Z,

Δ being 18½ A, the sun's altitude, and Z the zenith distance of P′, the neutral point below the sun.

An interesting paper, entitled *Delle Leggi della Polarizzazione della Luce Solare nella Atmosfera Serena, rammentando con Lettera al* DAVID BREWSTER, LL.D., F.R.S. Lond. *et* Edin., *membro della Principali Accademie di Europa*, del PROF. A.B. FRANCESCO ZANTEDESCHI, will be found in the *Raccolta Fisico-chimica Italiana*, tom. i. fascic. 10: 1846. The details in this paper are chiefly historical. The results obtained by M. Zantedeschi himself, which are of a general nature, differ in several respects from mine; but whether this difference arises from a difference in the methods of observation, or from the different states of the atmosphere under which the observations were made, I am not able to determine.

In a Memoir *on the Polarization of the Atmosphere*, which, I trust, will soon be published in the *Transactions of the Royal Irish Academy*, I shall give a full account of my observations, and enter more deeply into the subject than would have been proper in the preceding popular explanation of a Map of the Lines of Equal Polarization.

BOTANICAL GEOGRAPHY.

THE GEOGRAPHICAL DISTRIBUTION OF PLANTS,

ACCORDING TO

ALEXANDER VON HUMBOLDT, AND PROFESSOR SCHOUW.

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THE TEMPERATURE IS UNIFORMLY EXPRESSED IN DEGREES OF FAHRENHEIT'S SCALE.

INTRODUCTION.

A KNOWLEDGE of the laws by which vegetable forms are distributed over the surface of the globe constitutes Botanical Geography.

Every country, and frequently different parts of the same country, possesses a vegetation peculiar to itself; and the limits assigned to each region depend on various causes, since the variously modified organization of different vegetables imposes upon them different conditions of existence, and they can live and flourish only where these conditions are complied with.

The geography of plants, or an inquiry into their distribution, according to soil and climate, is intimately connected with the general physics of the globe, and is quite distinct from the science of descriptive botany. The importance of the former cannot be doubted, when we consider that the character of a country, and the whole face of nature, are dependent on the predominance of certain families of plants in particular districts, and that the abundance of *Graminem* (Grasses), forming vast savannahs, or of Palms or *Coniferæ*, produce the most important effects on the social state of a people—their manners—and the progress of the economical arts.

In considering the influence of temperature, which is the chief cause of variety in the distribution of plants, it is necessary to attend to the three following points: 1st, The mean temperature of the year; 2d, The extreme temperature, both as regards heat and cold; and, 3d, The distribution of temperature among the different months of the year, the last of which is most important, especially in reference to the heat and duration of the summer months; for many plants, protected from the action of the atmosphere by a covering of snow, are enabled to brave the most rigorous winters, and pass through all the phases of flowering and fructification, provided the summer be hot enough and of sufficient duration.

Every place on the surface of the globe receives, in the course of the year, a certain amount of heat from the sun; and from a comparison of this amount during a series of years, is deduced the mean temperature of the place.

Lines which pass through a series of places having the same annual mean temperature are called ISOTHERMS, or ISOTHERMAL LINES; those which pass through places where the mean winter temperature is the same, are called ISOCHEIMENES, or ISOCHEIMAL CURVES; and those which unite all places having the same summer temperature, ISOTHERES, or ISOTHERAL CURVES.

The lines of equal heat do not follow the parallel of the equator, but have convex and concave summits, which are distributed very regularly over the globe, forming different systems along the eastern and western sides of the Old and the New World, in the centres of continents, and in the vicinity of the ocean. Temperature determines the habitation of races, and consequently, the extension of the vegetable kingdom, the forms of plants, in general, presenting the same relations under the same isotherms; and as these lines form curves at unequal distances from the equator at different points in their course, so the vegetable zones, determined by the degree of temperature, follow their inflections.

"A knowledge of the number of plants of a single family in any particular place, may therefore afford a general idea of the remainder of the vegetation, if the isotherm be known, in the same manner as a knowledge of the total number of plants may serve to indicate the isotherm. But this general law is greatly modified by the operation of extreme temperatures, by which two points, placed under the same isotherm, often present the greatest difference of vegetation, namely, where the summer and winter temperatures vary little, and where they vary much; as on the coasts, and in the interior of continents. Thus, in North America, "taking the coast of New England, the region of the lakes, and the Pacific coast, the difference between the mean temperature of winter and spring varies from 0° 67 to 18° 42; whilst in the excessive climate of the regions west of the lakes, and intermediate to them and the Atlantic, the difference ranges from 18°, 82 to 30°, 83; and accordingly we find that spring and summer are confounded with each other, and that the sudden excess of heat renders the progress of vegetation almost perceptible."[2] It is evident, therefore, that isothermal lines cannot, any more than lines of latitude, rigorously determine a vegetable zone, but as certain divisions are necessary for reference and comparison, we have adopted the arrangement of Meyen, as the most accurate and convenient:—

ISOTHERMAL ZONES are spaces on opposite sides of the equator, having the same mean temperature, and bounded by corresponding isothermal lines. These have been proposed to supersede the old division of the surface of the globe into the torrid, the temperate, and the frigid zones, which was found quite inadequate in treating of the distribution of plants.

By this arrangement the surface of the globe is divided into eight zones or isothermal belts, in the following order:—

1st, The equatorial zone, on both sides of the equator of temperature, to about fifteen degrees of latitude, with a temperature extending from the maximum heat to 78°, 8.

2d, The tropical zone, from latitude 15° to the tropics, having a mean temperature from 78°, 8 down to 73°, 4; summer temperature 80° to 80°, 6; winter temperature in the eastern coast countries 59°.

3d, The sub-tropical zone, from the tropics to latitude 34°; mean temperature of the year 71°, 6 to 62°, 6; of the summer 82°, 4 to 73°, 4.

4th, The warmer temperate zone from latitude 34° to 45°; mean temperature of the year 62°, 6 to 53°, 6; summer temperature in North America 77°, in Europe 75°, 2 to 68°, in Eastern Asia 82°, 4; temperature of winter in the New World 44°, 6 to 32°, 54, in Europe 50° to 34°, 7, in Eastern Asia 26°, 6.

5th, The colder temperate zone, between the parallels of 45° and 58°; temperature of the year 53°, 6 to 42°, 8; minimum summer temperature on the west coast 56°, 31, in the interior of the continent 68°, minimum winter temperature in the interior of Europe 14°.

6th, The sub-arctic zone, from latitude 58° to the polar circle; mean temperature of the year between 42°, 8 and 39°, 2; of the summer months in the New World 60°, 2, in the Old World 60°, 8 to 68°; of the winter months of the former 14°, of the latter 24°, 8, namely, in Western Europe; in the interior of Russia 14°, to 10°, 4.

7th, The arctic zone, from the polar circle to latitude 72°; mean annual temperature 32° to 28°, 4 or, towards the eastern and continental positions, far under the freezing point.

8th, The polar zone, beyond latitude 72°. This parallel is near the mean temperature of 1°, 4 in the New World, and 16°, 7 in the Old World; the summer of the former 37°, 4, and of the latter 38°, 3; winter — 28° in the New, and — 2°, 2 in the Old World.

DESCRIPTION OF THE MAP.

I.—DISTRIBUTION OF PLANTS IN A PERPENDICULAR DIRECTION.

Mountains placed between the tropics, the summits of which ascend above the snow line, represent the vegetable zones of the whole earth, rising one above the other, in the same order as is observed in the direction from the equator to the poles.

Proceeding from the level of the ocean in the temperate and frigid zones, we perceive, as we ascend the slopes of mountains, that plants decrease not only in the size of individuals, but also in their number. At a certain height trees will not grow, still higher shrubs also disappear, and at the limit of snow, mosses and lichens alone are found. The same appearances are remarked under the tropics, with this difference, that here the mass of vegetation is found to be more limited in the plains than in the lower mountain regions. Such, also, is the case with the greater variety of species which, in common with these, decrease in an upward direction; and this remark is applicable to the other zones, especially the temperate; since in the cold zones the plants of higher regions cannot differ much from those of the plains, because the snow limits have but little absolute elevation. Besides, the distance of the limits of trees and shrubs from the snow line is greater in the torrid than in the temperate and frigid zones.

In central and southern Europe, the following difference is observed between the flora of the plains and that of the mountains of 4,220 feet elevation. The proportion of monocotyledones to dicotyledones, which in the plains is as 1 to 4, decreases with the elevation (but only on dry mountain slopes), till, at the height of 8,528 feet, it is as 1 to 7, and in particular cases even as 1 to 9. Moist mountain slopes, on the contrary, favour the growth of monocotyledones; here the proportion to the dicotyledones is as 1 to 3.

The tropical families which have representatives in the plains disappear altogether in the mountain flora, and this is also the case with those families which have their maximum number of species in the torrid zone. Examples of the first are found in the Palmæ and Aristolochiaceæ; and of the second, in the Malvaceæ, Aroideæ, Laurineæ, and Terebinthaceæ. Other families which have their maximum in the torrid, and decrease in the temperate zone, exhibit this decrease still more on the slopes of mountains, as exemplified in the Leguminosæ and Euphorbiaceæ. Among the families which have their maximum in the temperate zone, there are many which undergo but little change with increased elevation, as the Compositæ, Cruciferæ, Umbelliferæ, Rosaceæ, Stellatæ, Rubiaceæ, and the Ranunculaceæ; others of those families decrease as well towards the poles as towards the snow line, as the Liliaceæ, the Labiatæ, and the Gramineæ; and again others appear as under-groups, as the Alsineæ among the Caryophylleæ, which have their maximum in the higher regions.

Among other families the quotient is greater with increased elevation, as exemplified in the Carices, Amentaceæ, Primulaceæ, Gentianeæ, Saxifrageæ, Musci, and Lichenes.

In the European Alps, the Compositæ, from the number of species, are the prevailing family; after these follow, in nearly equal number, the Cyperaceæ, Alsineæ, Gramineæ, Cruciferæ, Leguminosæ, Rosaceæ, Saxifrageæ, and Umbelliferæ; but the mass of vegetation is formed by the Catkin-bearing plants (Amentaceæ), the Grasses and the genus Rhododendron of the Ericaceæ. As characteristic marks of the Alpine flora the following appearances may be noticed: 1st, The number of annual plants is very small; 2d, The flowers are of great size in proportion to the whole plants, and the colour of the flowers, as well as of the entire plants, is brighter and purer than in the plains.

Alpine plants afford more nourishment to the cattle than those of the plains; and plants with thorns, and very hairy plants, are seldom found in the Alpine regions.

On ascending a mountain in the torrid zone, we perceive that the higher we rise, the more the vegetation loses its characteristic features, and assumes those of other zones. On the Cordilleras of South America, the tropical families, as well as the Musaceæ, the Scitamineæ, the Cyneleæ, &c., disappear altogether at a height of 7,000 feet, or, like the Palmæ, only exhibit single representatives.

Families which have their maximum under the tropics, decrease in the number of species with the height, as is the case with the Malvaceæ, the Leguminosæ, Euphorbiaceæ, Urticeæ, Rubiaceæ, &c.; and families of the temperate zones, which nearly or altogether fail in the plains of the tropics, appear again in the higher regions, as the Umbelliferæ, the Cruciferæ, the Amentaceæ and Coniferæ, the Heaths and Ranunculaceæ; lastly, families which have their maximum beyond the tropics increase with the height, as the Compositæ, the Labiatæ, and Caryophylleæ. These proportions are still more varied in the species; among the 327 genera to which the plants on the declivity of the Andes, at a height of 7,000 feet and upwards, belong, 180, or more than the half, are common to the temperate zone.

As the physiognomy of the vegetable kingdom is characterized by certain plants in the different latitudinal zones from the equator to the poles, so also in a perpendicular direction, in the mountain regions, which correspond with the zones.

Proceeding from the vegetation of the equatorial zone, we follow the series of vegetable regions in ascending lines, one after the other, and may compare them with the different zones as follows:—

1. The region of Palms and Bananas,	Equatorial zone.	5. European trees,	Cold temperate zone.
2. Tree Ferns and Figs,	Tropical zone.	6. Pines,	Sub-arctic zone.
3. Myrtles and Laurels,	Sub-tropical zone.	7. Rhododendrons,	Arctic zone.
4. Evergreen trees,	Warm temperate zone.	8. Alpine plants,	Polar zone.

This comparison shows that each of the zones of higher latitudes possesses a region less than that which precedes it. Thus the tropical zone has only seven regions, whilst the Palms and Musaceæ, as characteristic marks of the vegetable physiognomy, disappear, and in their stead the Tree-Ferns in the lowest regions (New World) make their appearance; the warm temperate zone begins with the region of Evergreens, and has five regions above it. In the sub-arctic zone, the first five regions are wanting; its lowest is that of the Pines, above which there are two—those of the Rhododendron, and the various Alpine plants. This general scheme of vegetation, according to parallel and perpendicular directions, undergoes, however, some modifications from the peculiar localities of the mountains. The upper limit of trees in the equatorial zone is distinguished, not by *Coniferæ*, but by *Escallonia*, on the Andes of Quito, at a height of 11,500 feet above the level of the sea. *Alstonia* (*Synipicea*), the leaves of which yield a sweet, but very wholesome and strong tea, *Escallonia Tubar*, or *discolor*, and some of the Andromedas here shade low species of Lobelia, Bysella, and the everflowering *Saxifraga quadricornis* (Halenia asclepiadea). In the tropical region, on the high land of Mexico, the upper limit of trees rises to a height of 12,789 feet, and is distinguished by the western Pine (*Pinus occidentalis*).

In the temperate zone, the limit of trees is marked by the Oak, *Quercus semecarpifolia*, at 11,500 feet on the south side of the Himalaya mountains; and on the north side by the birch, *Betula alba*, at

[1] See Meteorological Division, Plate 1.

[2] Forry, Climate of the United States.

OUTLINES OF

BOTANICAL GEOGRAPHY.

THE DISTRIBUTION OF PLANTS

IN A PERPENDICULAR DIRECTION,

in the Torrid, the Temperate & the Frigid Zones;

WITH INDICATIONS OF THE

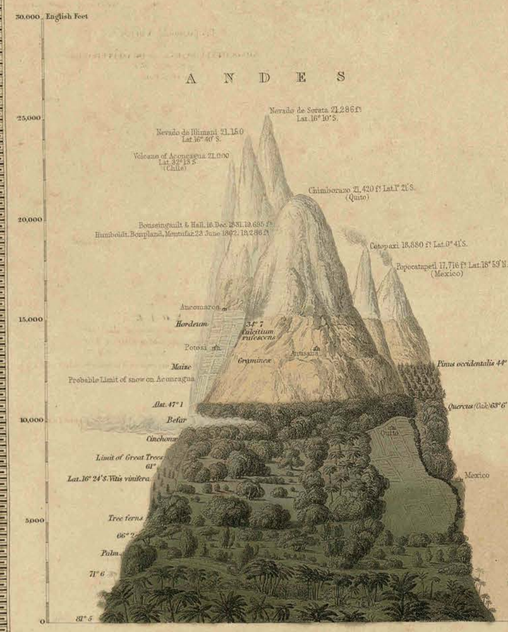
MEAN TEMPERATURE OF THE YEAR

AND OF THE COLDEST AND WARMEST MONTHS.

(Geographiæ plantarum Lineamenta, auct. A de Humboldt)

EXTENDED FROM THE DESIGNS OF PROFr BERGHAUS.

BY A.K.JOHNSTON, F.R.G.S.

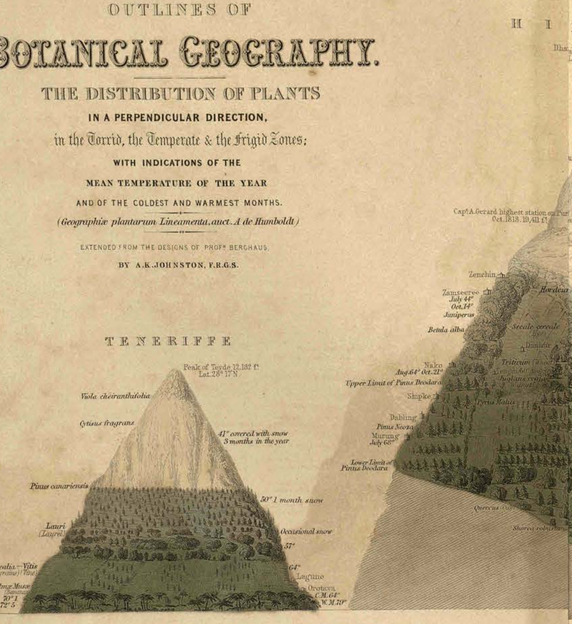


TORRID ZONE, LAT. 0°—10°

(Humboldt, Bompland, Pentland.)

LAT. 27½–28½

(Buch, Smith)


HIMALAYA
Jawahir 23,749 ft Lat. 30° 12'
Cap.t A. Gerard highest station on Peer Oct. 1818. 19,411 ft
Zemlehn Ch
Zanzeverer July 44° Oct. 34° Juniperus
Betula alba
Nagkon Aug 64° Oct. 23° Upper Limit of Pinus Deodara
Shipke
Pulbing Pinus Nivea
Murung July 68°
Lower Limit of Pinus Deodara
Quercus Ilex
Juniperus Rhododendron Betula alba, Sorbus, Quercus
Deotarah Temple
Upper Limit of Pinus Deodara
Bukhranli Temple
Upper Limit of Pinus Nivea.
Snow disappears before the rainy season. Tropical vegetation ceases
Lower Limit of Pinus Nivea
Nagkon 20,000 C.M. 40° 9' W.M. 60° 9
Quercus (Ilex)
Upper Limit of Pteris aquilina
Below this point Snow is Unknown
A. Spicatum 89° 2 C.M. 40° 6' W.M. 57° 4
Jukson
Rhododendron arboreum
Rhododendron campanulatum
Juniperus
Pinus Webbiana
Betula alba
Abies Smithiana
Pinus excelsa
Pinus Deodara
Cedrus Deodara
Pinus longifolia
Pinus Gerardiana
Abies Webbiana
Abies Pindrow
Pinus Smithiana

IX. Region of the Asiatic Islands, comprising the mountainous districts of the islands between the S. E. Peninsula and Australia, to a height of 5,500 feet above the level of the sea.
Mean Temperature, between 66° and 84°
The *cultivated plants* are the same as in the Indian Region (vii.), to which must be added the Mountain Rice, besides, Artocarpus incisa; Jatropha Manihot; Inocarpus edulis; Myristica moschata; Laurus Camphora; Carica Papaya; Gossypium arboreum vitifolium; Broussonetia papyrifera; Cannabis sativa.

X. The Region of Upper Java embraces those districts of the island of Java, and probably also the numerous islands of the Asiatic Archipelago, having an absolute elevation of 5,500 feet above the level of the sea. Cultivated plants not ascertained.

XI. The Polynesian Region comprises all the islands of the Pacific Ocean within the tropics.
Mean Temperature between 72° and 82°.
Cultivated Plants.—Artocarpus incisa; Caladium esculentum, sagittifolium; Arum macrorhizon; Taoca pinnatifida; Convolvulus chrysorhizus; Dioscorea alata; Cocos nucifera; Musa paradisiaca; Inocarpus edulis; Stercalia Balanghas; Ficus aspera, Granatum; Citrus decumana; Spondias dulcis; Mimusops dissecta; Terminalia glabra; Crataeva religiosa; Jambosa malaccensis. Dracaena terminalis; Piper methysticum; Areca oleracea; Broussonetia papyrifera.

XII. The Region of Balsam-Trees, embracing the south-western part of the highlands of Arabia or Yemen.
Cultivated Plants.—Sorghum sp.; Hordeum hexastichon; Zea Mais; Arum Colocasia. Phoenix dactylifera; Musa paradisiaca; Cocos nucifera; Tamarindus indica; Ficus Carica; Carica Papaya; Persica vulgaris; Armeniaca vulgaris; Prunus domestica; Pyrus Malus; Cydonia vulgaris; Vitis vinifera. Coffea arabica. Saccharum officinarum; Zingiber officinale. Raphanus sativus; Spinacia oleracea; Cucurbita Pepo; Dolichos sp. Gossypium arboreum; Indigofera tinctoria.

XIII. The Desert Region, Northern Africa to the south of the Atlas Mountains, between latitude 30° and 15° north, with the northern part of Arabia.
Mean Temperature 72° to 86°.
In this region cultivation is confined to the Valley of the Nile and the Oases. The principal plants are, Phoenix dactylifera; Sorghum vulgare; Triticum vulgare; Hordeum vulgare; the South European and some Indian grains.

XIV. The Region of Tropical Africa, comprising that part of the continent between latitude 15° north and the Tropic of Capricorn, or more correctly between the northern and southern limits of periodical rains, with the exception of Abyssinia and the unknown countries of the interior.
Mean Temperature 72° to 86°.
Cultivated Plants.—Zea Mais; Oryza sativa; Sorghum vulgare, saccharatum; Panicum sp.; Dioscorea alata, sativa; Jatropha Manihot; Caladium esculentum. Musa sapientum; Mangifera indica; Carica Papaya; Bromelia Ananas; Elais guineensis; Anacardium occidentale; Ficus sp.; Tamarindus indica; Citrus sp.; Coffea arabica; Saccharum officinarum, violaceum; Zingiber officinale; Amomum Cardamomum, Granum Paradisi. Phaseolus vulgaris; Dolichos oleraceus; Arachis hypogaea; Solanum edule, &c. Gossypium sp.; Nicotiana sp.

XV. The Region of Cactus and Pepper embraces Mexico and South America to the River Amazon, and to an elevation of 5,500 feet above the level of the sea, between latitude 30° north and the Equator.
Mean Temperature from 68° to 84°.
Cultivated Plants.—Zea Mais; Sorghum vulgare; Jatropha Manihot; Dioscorea alata; Convolvulus Batatas; Arracacha esculenta; Maranta arundinacea. Musa paradisiaca; Mangifera indica; Anona muricata, squamosa; Psidium pomiferum, pyriferum; Cocos nucifera; Carica Papaya; Persea gratissima; Bromelia Ananas; Anacardium occidentale; Tamarindus indica; Citrus sp.; Passiflora quadrangularis; Vitis vinifera; Opuntia vulgaris; Jambosa vulgaris. Theobroma Cacao; Vanilla aromatica; Coffea arabica; Saccharum officinarum, violaceum; Lycopersicum Humboldtii; Capsicum frutescens, annuum; Cajanus flavus; Arachis hypogaea; Opuntia coccinellifera; Nicotiana sp.; Gossypium barbadense.

XVI. The Region of the High Lands of Mexico embraces those districts which have an elevation of more than 5,500 feet above the level of the sea.
Mean Temperature between 78° and 64.°
Here Maize and European grains and plants are cultivated.

XVII. The Region of Cinchonæ (Medicinal Barks) embraces the region of the Cordilleras of South America, within the parallels of 5° north and 20° south latitude, at an elevation of from 5,500 to 9,000 feet above the level of the sea.
Mean Temperature between 68° and 59°.
Here the plants mentioned in the Region of Cactus and Pepper almost entirely disappear, whilst in the lower districts Maize and Coffee are still cultivated; and in the higher regions the European grains and fruits. To these the Potato and the Quinon succeed.

XVIII. In the Region of Escallonias and Calceolarias, which comprises the portion of the Andes chain with an elevation of more than 9,000 feet, between the same parallels as that of the Cinchonæ (xvii.) (5° north and 20° south), as well as the Andes of Chile beyond the Tropic of Capricorn; cultivation ceases.
Mean Temperature 59° down to 34°.

XIX. In the West Indian Region, which embraces the whole district of the Great and Little Antilles, the same plants are cultivated as those of the region of Cactus and Pepper (xv).
Mean Temperature 59° to 78°.

XX. The Region of the Palms and Melastomas consists of that part of South America east of the Andes chain, between the Equator and the Tropic of Capricorn.
Mean Temperature between 59° and 82°.
Here, also, nearly the same plants are cultivated as in the Cactus region, to which must be added the Tea shrub (Thea Chinensis), the culture of which is attempted in Brazil.

XXI. The Region of Arborescent SynantherÆ or Compositæ, comprises South America, on both sides of the Andes chain, from the tropic to latitude 40° south.
Mean Temperature from 59° to 75°.
Here the greater part of European plants form the objects of culture. Wheat, the Vine, and the Peach are widely extended.

XXII. In the Antarctic Region, embracing the southern part of America, Tierra del Fuego, and the Falkland Islands, there is no cultivation.
Mean Temperature between 41° and 46°.

XXIII. The Region of Scapellas and Mesembryanthemums, or Southern Africa, from the Tropic of Capricorn to the Cape Coast.
Mean Temperature between 55° and 73°.
Cultivated Plants.—European kinds of grain and fruit, and European vegetables; besides Sorghum Caffrorum; Convolvulus Batatas; Musa paradisiaca; Tamarindus indica; Psidium pomiferum; Citrus decumana.

XXIV. The Region of Epachrides and Eucalypti, or Australia beyond the tropics, with the Island of Tasmania.
Mean Temperature between 52° and 72°.
In the British Colonies, the European kinds of grain and fruit are cultivated.

XXV. The New Zealand Region, embracing the islands of that name.
Mean Temperature (between latitude 34° and 50° south) from 61° to 63°.
Cultivated Plants.—Caladium esculentum; Convolvulus chrysorhizus; Phormium tenax; Broussonetia papyrifera, and latterly European grains.

V.—DISTRIBUTION OF THE FAMILY OF PALMS, GENUS PINUS, &c.

I.—PALMÆ.—THE PALM TRIBE.

NAMES AND PROPERTIES.

This beautiful family of vegetables renders the most varied and valuable services to the inhabitants of the countries in which it abounds, including in itself the useful properties of almost all the other tribes of the vegetable kingdom. The wood is employed in the construction of huts, for which the leaves, with little labour, furnish roofs; and the flexible fibres serve for the manufacture of thread, cords, and cables, as well as defensive weapons and domestic utensils.

Many species yield excellent food nearly without preparation; entire populations are nourished almost exclusively on Dates, and the acidulated cream of the Cocoa nut affords a delicious drink in hot climates. The terminal buds of the *Areca oleracea*, known in the West Indies as the Cabbage Palm, furnishes a wholesome article of food, with a flavour similar to that of our Cabbage.

An abundant feecula in the interior cells of the trunks of a great number of species, especially the *Sagus Rumphii* and *Phoenix dactylifera*, is celebrated under the name of Sago.

The *Elais guineensis* affords the most esteemed kind of Palm wine, and Arrack is made from the juice of the *Areca Catechu* fermented with Rice. Palm oil is chiefly obtained from the *Elais guineensis*, already mentioned; and Palm wax is procured in great abundance from the trunk of the *Ceroxylon Andicola*.

But the *Murichi* or Ita Palm of Guiana, as described by a celebrated traveller,[1] appears to possess the most astonishing variety of useful properties. "The trunk and leaves are used for various household purposes. The sap is a saccharine fluid, much drunk by the natives. The flowers afford a sweet fermentable liquid, resembling champagne. The pith of its trunk affords a kind of Sago. Even in its decay the Palm is of use, and affords a delicacy to the Indians, which likewise many colonists do not refuse, namely, the larva of a large beetle. The *Curculio palmarum*, is found in large numbers in the pith when the trunk is near its decay, and which, when boiled or roasted, resembles in taste the marrow of a beef bone."

GEOGRAPHICAL DISTRIBUTION.

Palms contribute greatly to impress on the vegetatio of tropical countries its peculiar physiognomy. For a space of fifteen degrees on each side of the equator they form the characteristic vegetation; beyond this they are less numerous, and mixed, to a great extent, with the plants of more temperate regions.

The *Chamærops Palmetto* in latatitude 34°, marks the northern limits of the family in America. The limits of distribution in Europe appear to be defined by the *Chamærops humilis*, latitude 43°; and in Asia, as far as yet ascertained, the limit coincides with that of America, viz., 34° to 36° north.

In the Southern Hemisphere, they are found as low as latitude 38° in New Zealand. None have yet been discovered in South Africa, although they are abundant in South America at a corresponding parallel of latitude; nor was any species observed by M. Leschenault in Western Australia, even within the tropics.[2] They are abundant in almost all the islands of Polynesia, even where uninhabited.

Grows in South America, from the Llanos of Cumana to the western tributaries of the Rio Negre and the mouth of the Amazon, over an area of 550,000 square miles.

II.—GENUS PINUS.—THE PINE TRIBE.

To this order belong a great many of our most important forest trees; and, whether viewed in reference to their timber, which is considered equal to that of the Oak in point of utility and value, or their secretions, consisting of oil of turpentine, pitch, and Canada balsam, the Pine tribe is of the utmost importance to mankind. The timber is generally best in exposed, cold situations, and when of slow growth. It is known in commerce under the names of Deal (or White Fir), Fir, Pine, and Cedar. Spruce beer is made of a substance extracted from the branches of the Pinus canadensis, and the Pinus nigra; and the tanning powers of the Larch are said to be as great as those of the Oak; the large seeds of many of the species are eatable. The greater number of this order are found in temperate climates—in Europe, Siberia, China, and the temperate regions of North America, they are very abundant; but they are spread over various parts of the world, from the arctic regions of America to the Indian Archipelago.

I.—NORTH AMERICA.

NAMES AND PROPERTIES.

Pinus balsamea, (American silver Fir, or Balm of Gilead Fir) attains, to the height of 50 feet, and yields the resin called Canada Balsam.

Pinus nigra, (the black or double Spruce Fir). Timber valued for strength, lightness, and elasticity.

Pinus alba, (the white Spruce), yields timber of a large size, but not so resinous as the Norway spruce. Its bark is used for tanning.

Pinus rubra, (the Newfoundland red Pine), grows to the height of 30 feet—qualities of timber not ascertained.

Pinus Banksiana, (grey Pine or Labrador Scrub). Timber light, but not valuable.

Pinus microcarpa, (red Larch), a small tree; in the northern regions it is quite dwarfish, seldom above 6 or 8 feet high.

Pinus pendula, (pendulous Larch). The timber of this tree is not valuable.

Pinus canadensis, (Hemlock Spruce), a noble tree of slow growth, attaining an average height of 80 feet. Its timber is not good, but its bark is valuable for tanning.

GEOGRAPHICAL DISTRIBUTION.

The cold regions about Great Slave Lake and the Alleghany Mountains.

Inhabits the mountainous districts of Carolina and Nova Scotia, and some of the most inclement northern regions.

Abundant in Nova Scotia and Canada. Dr Richardson found it on the Coppermine River, upwards of 20 feet in height.

Nova Scotia, Newfoundland, and the Shores of Hudson Bay.

Nova Scotia, Canada, and Hudson Bay. It was found by Dr Richardson upwards of 40 feet high on the Mackenzie River, in 64° north latitude.

The shores of Hudson Bay, and the countries to the westward, as far as latitude 65° north.

Mountainous districts in North America.

Extends from the Alleghany Mountains to latitude 51° north; it is very abundant in Nova Scotia, New Brunswick, near Quebec, and in Vermont.

[1] Sir Robert Schomburgk.

[2] Brown, in Flinders' Voyage.

14,000 feet. This tree forms also the limit on the Caucasian mountains at 6,834 feet. On the Pyrenees and the Alps, the limit is marked by the Coniferæ; on the Pyrenees by *Pinus uncinata* at 10,870 feet; on the south side of the Alps by *P. Larix*, at 6,700 feet, and on the north side by *P. Abies*, at 5,883 feet of elevation.

In the cold zone, the *Betula alba* forms the upper limits of trees, at 1,918 feet, in Lapland.

The upper limits of shrubs, or the region of the Rhododendron, is in the Andes of Quito, distinguished by the *Befarias*, which represent the Rhododendrons of the Old World, and rise to a height of 13,420 feet.

On the south side of the Himalaya, the *Juniperus*, *Salix*, and *Ribes* tribes, form the upper limit of shrubs, at 11,500 feet; on the north side, the *Tamo*, a species of Broom (Genista versicolor), flourishes at 17,000 feet, and vegetation is prolonged to nearly 18,000 feet. The Rhododendron forms the upper limit of shrubs in the Caucasus at 8,825, the Pyrenees 8,312, the Alps 7,480, and in Lapland at 3,000 feet above the level of the sea.

II.—SECTIONS OF MOUNTAINS.

On the pictorial representation of the distribution of plants in a perpendicular direction, each group is placed at the elevation which nature has assigned it, enabling us to follow the infinite variety of forms, from the regions of Palms and Ferns to that of the Grasses and Lichens. The name of each family is placed at the upper, and sometimes also at the lower, limit of its vegetation; and the scale of English feet, to which all the diagrams are adapted, shows its elevation. The designs relating to the torrid zone, the Alps, Pyrenees, and Lapland, have been extended from A. Von Humboldt's Grundzügen der Pflanzengeographie. Names of cities and other places at considerable elevations, as well as the highest points attained by some of the most enterprising naturalists, are engraved in a lighter character, to distinguish them from those of plants.

The snow line and the limits of vegetation on the Andes of Bolivia, are laid down from Pentland's observations; and the Volcano of Aconcagua, from the measurements of Fitz-Roy and Pentland, who first ascertained its extraordinary elevation. Monte Rosa has also been added to the group of the Alps.

The diagram of the Himalaya Mountains exhibits the remarkable difference in the height of the snow line, and consequently of the limits of vegetation on the northern and southern sides. This difference amounts to 3,645 feet; the limit of snow on the north side being at an elevation of 16,625 feet, and on the south side 12,980 feet. On the north side, there is varied cultivation and good crops, at a height of 13,000 feet, and Captain Gerard found vegetation in full activity at an elevation of 18,800 feet (in latitude 32°), whilst on the southern side it hardly reaches 10,000 feet.[1]

Teneriffe and the Himalaya Mountains mark the transition from the torrid to the temperate zone, in which the Alps and the Pyrenees are situated.

In the ascent of the Alps, the plants, which at the base resemble those of the fields, gradually give place to others, more or less different, till the Walnut and Chesnut are succeeded by the Oak, the Beech, and the Birch tree. At about 2,600 feet the Oak ceases to grow, the Beech continues till about 3,200 feet; beyond this, the wood is formed almost exclusively of green trees—the Pine, the Larch, and the common Fir; these also cease at successive stages, to the elevation of 5,900 feet.

One of the Coniferæ, the *Pinus Cembra*) is observed sometimes to advance 300 feet farther; beyond this limit the trees are replaced by humble copse wood, as for example, by a species of Alder (*Alnus viridis*), which is surrounded by the Rhododendron—a shrub so characteristic of the region that it is called the Alpine Rose. This also soon ceases, and gives place to the so-called *Alpine plants*, which rise but little above the level of the soil.

At a still greater elevation, the rocks are covered with *Mosses* and *Lichens*, which, struggling up to the barrier of eternal snow, serve to vary the monotony of their surface.

In the mountain masses situated at different latitudes and in the most opposite parts of the globe, the upper zone of vegetation, bounded by the limits of snow, and which we have called the polar zone, everywhere presents the same physiognomy as that of the Alps. Mixed to a certain extent with a number of species peculiar to different countries, the original races are still the same. In Asia, the Altai, the Caucasus and Himalaya present the closest analogy. They are generally the same family, the same genera, but represented by different species, which are more varied in proportion as we recede from our standard of comparison, the Alps. In America those plants which, by extension are also called Alpine, but which would be more properly called *Andine*, belong still to the same families, some of them to the same genera, but the greater number to new genera, especially to those of many of the Compositæ and Umbelliferæ. Others, at the snow line represent different families, as the Oxalis and the Calandrinia, and even some of the Malvaceæ, are said to approach that limit.

III.—HUMBOLDT'S STATISTICS OF THE PRINCIPAL FAMILIES OF PLANTS.

The relative proportions of the most important families of plants, in the different zones, have been determined by Alexander Von Humboldt in the following order:—

1. The group of Glumaceæ, which unites in itself the plants of the three families of the Juncea, Cyperaceæ, and Gramineæ, increases from the equator towards the poles, forming, under the tropics, one-eleventh, in the temperate zone one-eighth, and in the frigid zone one-fourth, of the entire Phanerogamæ. The increase towards the poles is owing to the rushes and sedges, which are rare in proportion to the other Phanerogamæ in the temperate zone, and within the tropics.

The Juncew alone almost disappear within the tropics, forming only one-four hundredth of the whole phanerogamic plants, while in the temperate zone they form one-ninetieth, and in the frigid zone one-twenty-fifth. The Cyperaceæ alone under the tropics, in the New World, one-fiftieth; in the Old World one-twenty-second part, in the temperate zone one-twentieth, and in the frigid zone one-ninth.

The numerous family of the Gramineæ is equally distributed over the whole earth; it increases in a small degree towards the poles; between the tropics the grasses form one-fourteenth, in the temperate zone one-twelfth, and in the frigid zone one-tenth of all the Phanerogamæ. Besides, these families increase in the number of species from the equator toward the poles.

The Ericeæ under the tropics, in America, form one-hundred and thirtieth, in the temperate zone of the Old World one hundredth, of the New World one-thirty-sixth, in the frigid zone one-twenty-fifth: so also the families the flowers of which form a Catkin, or the Amentaceæ, which, in the torrid zone, form only one-eight-hundredth, are in the temperate zone in Europe one-forty-fifth, in America one-twenty-fifth, and in the frigid zone one-twentieth of the entire Phanerogamæ.

2. Four other families, namely, the Leguminosæ, the Rubiaceæ, Euphorbiaceæ, and Malvaceæ, have the maximum of their species in the torrid zone.

The Leguminosæ form, under the tropics one-tenth, in the temperate zone one-eighteenth, and in the frigid, one-thirty-fifth of all Phanerogamæ. The Rubiaceæ, under the tropics of the Old World, one-fourteenth, in the New World one-twenty-fifth, in the temperate zone one-sixtieth, in the frigid zone one-eightieth.

The Euphorbiaceæ, in the torrid zone, one-thirty-second, in the temperate one-eighteenth, and in the frigid zone one-five-hundredth.

The Malvaceæ, in the torrid zone, one-thirty-fifth, in the temperate one-two-hundredth, and in the frigid zone the plants of this family entirely disappear. In the great family of Rubiaceæ, one of its seven groups, that of the Coffee, forms one-third of all the Rubiaceæ of tropical America, whilst the group of the Stellatæ principally belong to the temperate zone.

3. The three families of Compositæ, Cruciferæ, Labiatæ, and Umbelliferæ, have the maximum of their species in the temperate zone, and decrease as well towards the equator as towards the poles. The Compositæ form, under the tropics of the Old World, one-eighteenth, in the New World one-twelfth, in the temperate zone of Europe one-eighth, in America one-sixth, and in the frigid zone one-eighteenth of all Phanerogamæ.

The Cruciferæ are almost unknown in the torrid zone, if we consider the mountain regions between 7,670 and 10,870 feet in height, where these plants scarcely form one-eight-hundredth of all Phanerogamæ. In the temperate zone their quotient in Europe is one-eighteenth, in America; on the contrary, only one-sixtieth; in the frigid zone one-twenty-fourth.

The Labiatæ form, under the tropics, one-fortieth, in the temperate zone, in Europe, one-twenty-fifth; in America, as within the tropics, in the frigid zone one-seventieth. The scarcity of this family, as well as the Cruciferæ, in the temperate zone of the New World, is a remarkable circumstance. The Umbelliferæ are seldom found within the tropics at a height under 7,673 feet. Above this elevation they form (with the exception of a very few in the plains) only one-five-hundredth of all Phanerogamæ. They form, in the temperate zone, one-fortieth, and are more numerous in Europe than in North America; in the frigid zone they form one-sixtieth.

4. Among the Acotyledones, the family of Ferns claims our attention. Contrary to the general law affecting the Cryptogamæ, this family decreases towards the poles; which is accounted for by the circumstance, that it requires a moist soil, and the shelter of warm woods. Under the tropics, it forms one-twentieth, and in the temperate zone, one-seventieth of all Phanerogamæ. In Arctic America the Filices are entirely wanting.

IV.—SCHOUW'S BOTANICAL DIVISION OF THE GLOBE INTO TWENTY-FIVE PHYTO-GEOGRAPHIC REGIONS.

Among the attempts which have been made to arrange the peculiar vegetation of certain countries into botanical circles, or particular floras, that proposed by Professor Schouw "one of the authors who has occupied himself much with the geography of plants, and contributed most to its advancement," has met with peculiar favour. This division is based on the natural system of classification, without the assistance of which botanical geography would be lost in endless details.

It is founded on the three following requisites:—

1. That at least one-half of the known species of plants of that part of the earth constituting a botanical region should be peculiar to it.
2. That a fourth part of the genera of the region should either be peculiar to it, or at least should have so decided a maximum that if found in other regions, they should only be considered as rare representatives of it, whilst they are frequent and numerous in that region which their presence serves to define.
3. That individual families of plants should likewise be either peculiar to the region, or at least have a decided maximum there.

On these principles, Professor Schouw first proposed 18, and latterly 25, phyto-geographical regions, in which he has substituted, for the provincial divisions, the names of botanical or geographical regions in connection with those of the principal botanists or naturalists by whose researches the several floras have been made known. These regions, which are distinguished by different colours on the Map, are arranged as follows:—

I. The Region of Mosses and Saxifrages, or the Arctic Alpine Flora, embracing the north polar lands from the limits of ice to the region of trees, as well as the upper regions of the mountains of Europe and Northern Asia, from the snow line likewise down to the region of trees.

Mean Temperature:—Polar Lands, 66° to 41°.
" Mountain Regions, 47° to 36°.

In this region there is no cultivation.

II. The Region of Umbelliferæ and Cruciferæ, extending over Northern Europe and Asia from the southern limits of the first region to the Pyrenees, the Alps, the Balkan Mountains, the Caucasus, and the Altai.

Mean Temperature, 36° to 57°.

Cultivated Plants.—Secale cereale; Hordeum vulgare, hexastichon, distichon; Avena sativa; Triticum vulgare, Spelta; Zea Mais; Panicum miliaceum; Solanum tuberosum; Polygonum Fagopyrum. Pyrus malus, communis; Cydonia vulgaris; Cerasus vulgaris, avium; Prunus domestica; Armeniaca vulgaris; Persica vulgaris; Morus nigra; Juglans regia; Vitis vinifera; Ribes rubrum, Grossularia, nigrum; Fragaria vesca; Cucumis Melo. Brassica oleracea, Rapa; Raphanus sativus; Sinapis nigra, alba; Pisum sativum; Phaseolus vulgaris; Faba vulgaris; Ervum Lens; Spinacia oleracea; Beta vulgaris; Cucumis sativus; Cucurbita Pepo; Carum Carui; Daucus Carota; Humulus Lupulus. Linum usitatissimum; Cannabis sativa; Brassica Napus. Trifolium pratense, repens; Vicia sativa; Medicago sativa; Lolium perenne. Nicotiana Tabacum.

III. The Region of Labiatæ and Caryophyllæ, comprising the countries of the Mediterranean Sea, the three peninsulas of Southern Europe (of which the Spanish, including the south of France, is the country of aromatic plants, as Labiatæ and Corymbiferæ; the Italian, that of Leguminosæ) the Grecian Islands, Asia Minor, Egypt, and the whole of Northern Africa, to the Sahara and the great Atlas chain, except Madeira, the Canary Isles, and the Azores. The upper mountain regions belong to the first, and the middle to the second region.

Mean Temperature, from 54° to 72°.

Cultivated Plants.—In the second region, with the addition of Oryza sativa; Sorghum vulgare; Panicum italicum. Ficus Carica; Amygdalus communis; Pistacia vera; Citrus Limonum, Medica, vulgare, Aurantium; Opuntia vulgaris; Cucumis Citrullus; Olea europæa. Solanum Melongena, Lycopersicum; Pimpinella Anisum; Coriandrum sativum; Gossypium herbaceum; Morus alba; Crocus sativus; Rhus Coriaria. Lupinus albus; Onobrychis sativa. But, Secale cereale, Ribes rubrum; Grossularia, nigrum; Polygonum Fagopyrum; and Humulus Lupulus, are rare, and only found in the mountain regions.

IV. The Region of Asters and Solidagos extends over the northern part of North America, from the limits of the first region to the parallel of 36° north.

Mean Temperature, from 54° to 72°.

In the northern districts to the parallel of 55° or 56° there is no cultivation; south of this line, the cultivation is the same as in the second region; Maize, however, is cultivated to a greater extent in North America than in Europe.

V. The Region of Magnolias embraces the southern part of North America, between the parallels of 36° and 30°, where nearly the same plants are cultivated as in the third region, with the addition of the Olive Tree. Rice is also cultivated to a great extent. In the southern districts, Saccharum officinarum (the sugar cane) is the object of a productive culture, and in the eastern districts Cotton is grown to a great extent. The vicinity of the tropics is unknown.

Mean Temperature, from 59° to 72°.

VI. The Region of Camellias and Celastrales, comprising Japan and the northern part of China, between the parallels of 30° and 40° north.

Mean Temperature, from 54° to 68°.

Cultivated Plants.—Oryza sativa; Hordeum vulgare; Avena sativa; Sorghum vulgare; Eleusine coracana; Polygonum Fagopyrum; Cycas revoluta; Caladium esculentum; Convolvulus edulis. Pyrus Malus, communis, lacvata, spectabilis; Cydonia vulgaris; Prunus domestica; Cerasus vulgaris; Armeniaca vulgaris; Persica vulgaris; Eriobotrya japonica; Citrus japonica, decumana, Aurantium, nobilis, margarita; Cucumis Melo; Thea chinensis. Brassica Rapa, orientalis; Raphanus sativus; Cucumis sativus, Conomon, Citrullus, Cucurbita Pepo; Pimpinella Anisum; Illicium anisatum; Soja hispida; Phaseolus vulgaris, radiatus; Pisumsativum; Faba vulgaris; Solanum æthiopicum; Sesamum orientale; Cannabis sativa; Broussonetia papyrifera, Gossypium herbaceum.

VII. The Region of Scitaminer, or the Indian Flora, comprising India, with the island of Ceylon, and the S. E. Peninsula, to the height of 4,500 to 5,500 feet above the level of the sea.

Mean Temperature, between 65° 75 and 81° 50.

Cultivated Plants.—Oryza sativa; Panicum frumentaceum; Eleusine coracana; Sorghum sp.; Cyrus circinalis; Dioscorea alata; Arachis hypogæa. Cocos nucifera; Tamarindus indica; Mangifera indica; Garcinia Mangostana; Musa paradisiaca, sapientum; Jambosa vulgaris, malaccensis; Psidium pomiferum; Citrus Aurantium, decumana; Cucumis Citrullus; Saccharum officinarum; Coffea arabica; Caryophyllus aromaticus; Piper longum, nigrum, Betle, Cubeba; Zingiber officinale; Alpinia Cardamomum; Curcuma longa; Cinnamomum Zeylanicum. Soja hispida; Phaseolus sp.; Dolichos sp. Gossypium herbaceum. Indigofera tinctoria, Anil. *The latter imported from South America to India.*

VIII. The Exotic Region, or the Alpine Region south of the ridge of the Himalaya, embracing Sirmore, Gurwal, Kumaon, Nipaul, and Bhotan, to a height of from 4,500 to 10,7000 feet above the level of the sea.

Mean Temperature, from 60° to 37°.

The *cultivated plants* are of the European grain and fruit kinds, with some tropical plants in the lower districts; among others the Mountain Rice, a variety of the Oryza sativa.

[1] Humboldt, Asie Centrale. Gerard's Koonawar.

NAMES AND PROPERTIES.	GEOGRAPHICAL DISTRIBUTION.
PINUS RESINOSA (Pitch Pine, or red Pine of the Canadians), remarkable for its great height, and its smooth red bark, and yields a great quantity of fragrant resin.	Canada, and the northern regions of America. It grows in close forests
PINUS STROBUS, (white or Weymouth Pine), this is the largest species to the east of the Rocky Mountains, being found to attain to 200 feet in height. Timber valuable for ships' masts.	Canada, and the United States, about Lake Champlain, on Family Bay, &c.
PINUS RIGIDA, (the pitch Pine.) Timber cross-grained and of inferior quality, but yields abundance of tar.	Found in the greater part of the United States, on poor soils.
PINUS LAMBERTIANA, (the Lambert Pine). This enormous tree grows in poor sandy soils where there is no other vegetation, and arrives at a height of more than 200 feet. Its timber is only fit for fire-wood; the seeds are roasted for food, and made into cakes for winter use. A recumbent specimen measured by Mr Douglas was found to be 215 feet long.	New Albion, North-west America.
PINUS PONDEROSA, (heavy-wooded Pine.) Timber heavy and durable, but coarse.	North-west America.
PINUS DOUGLASII, (the Douglas Pine), a gigantic tree, growing to a height of upwards of 200 feet, with a rough bark; its timber is of good quality, and very heavy.	Discovered by Mr Douglas on the banks of the Columbia River, in vast forests, extending from the Rocky Mountains to the shores of the Pacific Ocean.
PINUS SABINIANA, (the Sabine Pine), a noble tree, 110 to 140 feet high. Timber soft, white, and not durable.	California.
PINUS INSIGNIS, (the noble Pine), a beautiful species, characterized by bright grass-green foliage.	California.
PINUS MITIS, (variabilis), (the yellow Pine.) Timber very durable; used in naval and domestic architecture.	Middle and northern parts of North America.
PINUS INOPS, (the Jersey Pine or Scrub Pine.) Timber of little use except for fuel.	Southern districts of United States.[1]
PINUS AUSTRALIS, (the southern Pine.) Timber light, clean, and durable, used for masts of ships, and yields abundance of tar.	Middle countries of North America.
PINUS GRANDIS, (the great Californian Fir), said to attain a height of 200 feet; wood soft, white, and of an inferior quality.	California.
PINUS RELIGIOSA, (the sacred Mexican Pine), grows on the hills to the highest limits of arborescent vegetation.	Mexico.
PINUS FILIFOLIA. Qualities of timber unknown.	Guatemala, Central America.
PINUS HUMBOLDTELLA, (the hairy Fir), a small tree which grows on the mountains at an elevation of from 800 to 900 feet.	Mexico.
PINUS TEDA, (the frankincense Pine) attains a height of 80 feet—timber soft, and not durable; but it yields abundance of fragrant turpentine.	The barrens of Florida and Virginia.
PINUS OCCIDENTALIS (West Indian Pine).	West India Islands; on St Domingo, of which it is a native, it grows on the mountains where snow sometimes falls.

2.—EUROPE.

PINUS SYLVESTRIS, (the Scotch Fir). This is the hardiest and most valuable of all the Pines; its timber furnishes the red and yellow Deal of the carpenters. Its resinous products—tar, pitch, and turpentine—are very valuable. It grows to the height of 80 or 90 feet.	The mountains of Scotland and Northern Europe. It is abundant in Scandinavia, Siberia, and North America.
PINUS LARIX, (the common Larch). Next to the Scotch Fir this is the most valuable of the tribe; its timber is heavy, tough, and compact; its average height is about 45 feet.	A native of the mountains of middle Europe, widely diffused over Russia and Siberia, where it is the most common of all trees. It is extensively cultivated in England and Scotland, on barren and exposed land.
PINUS ABIES, (the Norway Spruce). This noble tree rises in a straight stem from 150 to 200 feet in height. Its timber is known as the white Fir or Deal.	The countries of northern Europe; it is the principal tree of Norway, and is found throughout Siberia to 70° north latitude.
PINUS PICEA, (the silver Fir). A large tree, the timber of which is of good quality, and much used for ship-building and carpentry.	A native of the mountains of Siberia, Germany, Switzerland, and Italy.
PINUS PINEA, (the stone Pine). The timber of this tree is used in ship-building, and its large seeds are eaten.	Southern Europe and the Levant.
PINUS PINASTER, (the cluster Pine). This noble species affords a great quantity of rosin and tar; but its timber is light, soft, and coarse.	Inhabits the barren plains of France and southern Europe, especially in coast districts.
PINUS UNCINATA, (the hooked Pine). An Alpine species, valuable for the hardness and durability of its timber.	Pyrenees and other mountainous districts of Europe.
PINUS PYRENAICA, (Pyrenean Pine). A majestic tree, the timber of which is said to be of excellent quality, and much used in the Spanish navy.	Pyrenees, and other mountainous districts of Spain.
PINUS AUSTRIACA, (the black Pine). Timber, valuable, but of a coarse description.	Inhabits rocky and sterile districts in southern Germany.
PINUS PALLASIANA, (the Pallas Pine). Timber durable, but very knotty.	The Crimea.
PINUS LARICIO, (Corsican Pine). This tree grows very fast, and yields excellent timber.	Mountains of Corsica, Spain, Greece, and Turkey.
PINUS CANARIENSIS, (Canary Pine). Timber resinous and durable.	Mountains of Canary and Teneriffe.

3.—ASIA.

PINUS CEDRUS, (the Cedar of Lebanon). The timber of this most majestic and stately tree is said to be almost indestructible, and is so bitter that no insect will touch it. It is not a very tall tree, but its branches spread over a great extent. In England it has attained the height of 53 feet. The Keloo, which Gerard conceives to be the Cedar of Lebanon, grows on the Himalaya Mountains to a height of 150 or 200 feet. "It would be invaluable in the plains of India, as it resists the attack of the destructive white ant."[2]	Mount Lebanon, and the other mountains of Syria, the Taurus range, and the Himalaya Mountains.
PINUS HALEPENSIS, (Aleppo Pine). A beautiful species of Pine characterized by light-green foliage. Its timber is not valuable.	Syria, and the countries of Eastern Europe.
PINUS CEMBRA, (the Cembra Pine). Timber fine-grained and soft.	The sides of mountains in Siberia, Tartary, and Switzerland.
PINUS SIBIRICA, (Siberian silver Fir). The Pichta of the Russians.	Mountainous regions of Siberia.
PINUS NEOZA or PINUS GERARDIANA, (the Neoza Pine). A large tree of a conical and compact form. It is called *Ree* by the natives, and produces the Neoza almond, which is said not to grow except between the snowy mountains.	Inhabits the dry and cold face of the Himalaya Mountains, on the Tartarian side.
PINUS DEODARA, (the Indian Cedar). Timber close-grained, durable, and very resinous.	The Alps of Nepaul and Tibet, at a height of from 10,000 to 12,000 feet.
PINUS EXCELSA, (the lofty Pine).	Himalaya Mountains.
PINUS WEBBIANA, (spectabilis), (the Webb Fir). This tree grows to a height of 80 or 90 feet, and its timber is said to be very valuable.	The cold regions of Northern India.
PINUS BRUNONIANA, (deciduous silver Fir). The wood of this tree is of inferior quality; it attains the height of 70 or 80 feet.	Northern provinces of India.
PINUS LONGIFOLIA, (long-leaved Pine). A very beautiful species, but tender; the seeds are large and eatable.	The lower hills and valleys of Nepaul.
PINUS SMITHIANA, (Smith's Pine). This is described by Wallich as of enormous size, but its properties are not ascertained.	Mountains adjoining the Himalaya.
PINUS ORIENTALIS, (Eastern Pine). Properties not ascertained.	Asia Minor and Georgia.
PINUS SINENSIS, (Chinese Pine). Said to attain a great height, but little known.	Hilly grounds of China.

III.—GENUS ERICA.—THE HEATH TRIBE.

This extensive and beautiful Genus of Plants, including a great variety of species, is entirely confined to the countries of the Old World, no species having yet been discovered in America. It is most abundant at the Cape of Good Hope, in northern Europe, and the countries bordering on the Mediterranean. In Britain Erica or Calluna vulgaris (Heather) covers great tracts of waste lands. It is not common in Indian or Northern Asia, and is almost unknown in Australia.

NOTE ON THE PROGRESS OF BOTANICAL GEOGRAPHY.

OBSERVERS who, in a short period of time, have passed through extensive districts of country, and who have ascended mountain-ranges, on which climates are placed in layers one over the other, must soon have become aware of the regular distribution of vegetable forms. They gathered raw materials for a science, the name of which had not yet been pronounced. The same regions of plants which, as a youth, Cardinal Bembo described on the declivity of Etna in the sixteenth century, were again found by Tournefort on Ararat, who accurately compared the Alpine flora with that of the plains under different latitudes, and was the first to remark, that the elevation of the soil above the level of the sea affects the distribution of plants, in the same manner as distance from the poles in level countries. Meyen, in an inedited Flora of Japan, casually makes use of the term, Geography of Plants. This phrase is again found in the fantastic, though charming, "Studies of Nature" by Bernardin de St Pierre. But, the scientific treatment of the subject only commenced when the Geography of Plants was considered in intimate connection with the doctrine of the distribution of heat over the surface of the globe; when plants were arranged in natural families, so as to admit of the numerical computation of the forms which decrease or increase towards the poles, and what proportion, in different parts of the earth, each family bears to the whole mass of the indigenous Phanerogamæ.[1]

Justus remarks, that, notwithstanding several essays before his time, A. Von Humboldt deserves to be pronounced the founder of the system of the Geography of Plants, on which he has thrown so much light, by his labours on meteorology as well as botany. His name is therefore placed first in the following list, in which, besides indicating the authorities for the facts stated in the preceding Map and Notes, we have referred to several more popular works, in which the subject is treated more or less systematically.

Humboldt, Essai sur la Geographie des Plantes. Paris, 1807.
" De Distributione Geographica Plantarum, &c. Paris, 1817.
" Asie Centrale. Paris, 1843.
" Kosmos, Stuttgart, 1845.
Schouw, Grundzüge der Pflanzengeographie, p. 507–524. Berlin, 1823.
" Memoria su cinor Verlsning iiber die Pflanzengeographischen Reiche, in Schlechtendal's Linnæa, viii. Band. 1833.
Berghaus, Länder und Völkerkunde, iii. Band. Stuttgart, 1836.
" Grundriss der Geographie, i. Band. Breslau, 1843.
" Physikalischen Atlas.
Jussieu, Botanique. Paris, 1844. De Candolle in Dictionnaire des Sciences Naturelles, t. xviii.
Wallich's Flora Indica, Royle's Illustrations of the Botany of the Himalaya Mountains. London, 1840.
Gerard's Koonawur. London, 1841. Asiatic Researches—various Papers.
Lindley's Introduction to Botany. London, 1835.
" Natural System of Botany. London, 1836.
Lyall's Principles of Geology, vol. ii.
R. Brown's Botany of Terra Australis (appendix to Flinders' Voyage), 1814.
Edinburgh Philosophical Journal, vol. vi., &c.—various Papers from Humboldt and Schouw's Works.
Hooker, in Murray's Encyclopædia of Geography. London, 1834.
Traill, in Encyclopædia Britannica. Edinburgh, 1842.
Balfour, in Malte Brun and Balbi's Geography. Edinburgh, 1842.
Forry's Climate of the United States. New York, 1842.
Lamouroux, Geographie Physique. Paris, 1825.
Lambert on the Genus Pinus.—Annales des Sciences Naturelles.
Memoires de l'Academie de Bruxelles, &c.

[1] Gerard's Koonawur, p. 65.

[2] Kosmos, i. Band, S. 374.

GEOGRAPHICAL DISTRIBUTION AND CULTIVATION

OF

THE MOST IMPORTANT PLANTS

WHICH ARE USED AS FOOD FOR MAN.

WITH INDICATIONS OF THE ISOTHERES AND ISOCHIMENES OR CURVES OF EQUAL SUMMER AND EQUAL WINTER TEMPERATURE.

INTRODUCTION.

INVESTIGATIONS into the native country, the geographical distribution, and uses of the most important cultivated plants, considered as objects of nourishment, luxury, and commerce, form an important part of Botanical Geography. This subject is ably treated in the ingenious work of Meyen,[1] and in a learned and interesting essay by Decandolle.[2] Of the valuable materials furnished in these works, as well as in those of Schouw, Ritter, and others, we have availed ourselves in the following notes, and in the construction of the accompanying map; which may be considered as a companion to the Chart of Botanical Geography, No. 1. of this division.

The object of this plate is to give a general view of the geographical distribution of those plants which are more especially adapted for food to man. The large map shows the districts occupied by the different kinds of grain, and the manner of its distribution over the globe. It is hardly necessary to observe, that the regions indicated by colours are not so distinctly bounded in nature as they are represented on the map; in general, that kind of grain which is pointed out by a particular colour, does not occur exclusively, but only prevails. Thus, other kinds of grain besides rye, are cultivated in the regions indicated by the orange colour; but there rye forms the principal article of food from the vegetable kingdom. Wherever two kinds of grain occur in nearly equal proportions, the fact is indicated by the presence of the colour referring to each, as explained in the table on the map. The centre of the lower part of the sheet is occupied by four small maps of different portions of the globe, indicating the distribution of tea, coffee, sugar, spices, &c.; and on the margins are given representations of the forms of some of the principal plants.

Although observations on the temperature of the different seasons are as yet very few in number, and little to be depended on, still it was thought desirable to make a first attempt to delineate on the present map the curves of equal summer heat (*Isotheres*), and equal winter cold (*Isochimenes*),[3] since a knowledge of these is indispensable, in order to ascertain the possibility of cultivating certain plants.

Spontaneous plants, says Decandolle, are distributed on the surface of the earth according to purely physical and physiological laws. When a species exists, on any part of the globe (in consequence of a little known primitive distribution) it spreads with a variable intensity, according to its more or less prolific organization, and the physical circumstances, favourable or unfavourable, by which it is surrounded. In the origin of existing plants, these causes must have rapidly extended and modified the limits of each species. Subsequently, the new generations brought on important changes in the organization of beings, and as no sensible alteration had occurred in the physical circumstances, such as the configuration of the soil, temperature, &c., species arrived, in their geographical distribution, at a sort of permanence or equilibrium. At present, indeed, if there be no intervention on the part of man, it seldom, if ever, happens that a species spreads spontaneously, and maintains itself beyond the geographical limits known from the earliest times. When this happens by accident, the strange species is almost always destroyed by some subsequent change of climate, or arrested in its progress by the compact mass of vegetation which already covers the soil. Considered in their natural state, the species which we cultivate are subjected to the same laws. Like all plants, they have a special habitat, within which they develop themselves spontaneously; that is to say, without the intervention, direct or indirect, of the human species. If this natural part is sometimes difficult of recognition, it must be attributed to certain circumstances, which greatly complicate the history of plants submitted to our control.

Independent of this, a great number of cultivated species—of that country where they have always grown without the help of man—they have what may be called an *artificial* country, where they cannot live and re-produce themselves without the care which we bestow upon them. We may distinguish in the latter, also, an *agricultural* and a *horticultural* station, according as we treat of plants as cultivated in open fields or in gardens. The stations of spontaneous plants, or what may be called their natural limits, vary little, because they depend on causes which are almost uniform during many centuries. But this is not the case with artificial stations; their limits must extend, according to the industry and the wants of man, modified in each locality and at every epoch, by commercial causes, by laws and regulations, and even by custom and the caprice of fashion.

Horticulture especially extends the artificial limits to an indefinite extent, because the special care bestowed on a garden or hot-house is, so to speak, unlimited. If the temperature of the hot-house could be lowered, as easily as it can be elevated, there would be nothing to prevent the cultivation, in any region, of all the species which exist on the surface of the globe. The agricultural limits are at once more confined and more fixed. They cannot be extended beyond a certain space, because the agriculturist has no power over the general conditions of the temperature, light, and moisture of the country he inhabits. No doubt, by well-directed labour, he can modify some of the circumstances of climate, and thus some of the limits of cultivation may be advanced. But the curve of the agriculturist are themselves limited by the necessity of obtaining a certain product, proportioned to the expense of culture. Thus, it is the net revenue which determines the agricultural limit of species, at least, when it concerns plants which have been cultivated for ages, and a country where agriculture is generally established. Now, the net produce depends, 1st, On botanical and physical causes, connected with the geography of plants; 2d, On industrial, commercial, legislative, and other causes, which belong to the domain of the moral and political sciences. Certain kinds of cultivation are very little influenced by political and commercial circumstances; others, again, almost entirely depend on them. When the question concerns voluminous products, of moderate value and of great consumption, as the principal alimentary substances, it is evident that transport enhances their price so much, that agriculturists will be anxious to produce them in every country. Then, the limits of cultivation are pushed as far as physical conditions will permit. If, on the contrary, the question concern commodities of a high price, of which the consumpt is less, which are lighter, and can be more easily transported, the interest of certain populations would be, to produce, and not to import them from countries more favourable to their culture. In every locality the produce of which is inferior in price or in quality to that which is imported, is abandoned. On the one hand, the potatoe and maize, which, in comparison with wheat, are new in the Old World, have spread by degrees, like that precious cereal, to the extreme possible limits, and become general everywhere. Whilst, at the same time, and by an inverse movement, the cultivation of the sugar-cane has disappeared from Spain, Sicily, the Canary Islands, and the northern coast of Africa; and that of the vine has retrograded in the north-west of France, and disappeared in England.[4] The cultivation of the olive has also receded in some localities of the south of France and north of Italy. It is in vain to attempt the explanation of this retrograde movement by the modifications of climate, tending, for example, from tillage, or the cutting down of forests. It is not the climate which has changed, but political, commercial, and industrial circumstances, have simultaneously produced a variation in the agricultural limits of species.

Bad vines may formerly have been cultivated in Normandy, in England, and even on the lower Vistula, and in East Prussia; because the wines of Bordeaux, and those of Portugal, could not then be easily imported. At that period, a thousand dangers and difficulties impeded both maritime and inland commerce, and each population was thrown back upon itself all that was useful or agreeable to it, without having recourse to foreign countries. Physical circumstances act ordinarily on a cultivated as on a spontaneous plant, so that many of the laws of botanical geography apply equally to both. A species is cultivated first in the region which it inhabits naturally, and there it succeeds better than anywhere else. Thus, the simple fact, that the tea plant grows spontaneously in the Indian province of Assam, would augur that its cultivation would succeed there as well as in China. Cultivation almost always produces agricultural limits much more extended than the natural limits of species. The potatoe, which is cultivated everywhere, is limited in nature to a small portion of South America. It is nevertheless true, that there is almost always a relation between the natural and agricultural limits of vegetables. The difficulty of cultivating a particular species is greater, in proportion as its natural district is limited. This is evident, since the small natural extent of the species indicates, that in order to its existence, very special physical conditions are requisite. As to the choice of country in which it may be desirable to attempt a new cultivation, it is evident that the geographical distribution of species ought to be taken as the guide. Here the connection between botanical geography and agriculture cannot be mistaken.

SPECIES WHICH HAVE THEIR ORIGIN IN THE OLD WORLD.

GRAMINACEÆ (*Grain* or *Cereal* grasses).[5]—Some of the plants of this order are among the most useful and the most anciently cultivated in Europe. They have had probably, in their origin, a very extensive natural country; because it is the property of species of this family, when left to themselves, to extend their limits. Barley grows spontaneously in Tartary and Sicily, two countries very distant from each other.

Many indications, botanical and historical, warrant the presumption, that Tartary and Persia are the native countries of wheat, rye, and oats. Several Greek and Roman authors believe wheat to be a native of Sicily; but this opinion has been confuted. Strabo, more exact than the writers of antiquity, says that it grows spontaneously on the banks of the Indus; but this region is still so little known, that modern botanists can neither affirm nor deny the assertion: although the genus *Triticum* is sufficiently spread over the whole of Asia to render the fact probable. Oats and rye may yet be found, also, growing spontaneously in some part of Asia which has not been explored.

If, after a century or two of new and scrupulous research, wheat, oats, and rye, are not found in a natural state in any region on the surface of the globe, it must be concluded, either that their primitive country has disappeared under water, which is not at all improbable, or that this country was on the banks of those rivers the waters of which, rice, oats, and rye, have been cultivated to the greatest extent since the remotest antiquity. Agriculture must have usurped their station to an extent which renders it impossible to distinguish on the same soil, the successors of those plants which formerly grew there spontaneously, from cultivated species. The natural countries of many of our cereals are therefore unknown, and will probably remain so for ever.

BARLEY (*Hordeum*) is cultivated further north than any of the other grains; fields of it are seen at the northern extremity of Scotland, in the Orkney Islands, and in Shetland (lat. 61° N.), and even at the Faroe Islands (lat. 61° 30′ to 62° N.), and in Iceland (lat. 63° 20′ to 66° N.), where it is almost the only an industrious population have every exertion to acquire some species of cerealia. In Western Lapland, the limit of barley, is under lat. 70°, near Cape North, the northern extremity of Europe. In Russia, on the shores of the White Sea, it is between the parallels of 67° and 68° on the western side, and about 66° on the eastern side, beyond Archangel. In Central Siberia, between lat. 58° and 59°. Such is the sinuous curve which limits the cultivation of barley, and consequently that of all the cereals. A little farther north, all employment of vegetables ceases, at least as an important object of nourishment; the people live on the product of their cattle, as in the high Alps, or by hunting and fishing, according to locality. But beyond the limits of barley there occurs a narrow and indeterminate zone, in which certain early potatoes are cultivated, and where the snow does not cover the ground for a sufficient length of time to prevent the raising of some lichens, some fruits, barks, or wild roots, fit for the nourishment of man. As the introduction of the potatoe is, in consequence to barley, recent in these regions, it almost everywhere forms the limit between the agricultural and the pastoral or nomad life. From the importance of the cultivation of barley in the north, it is evident that wherever the human species has attained the first stage of civilization, the attempt will have been made to advance it as far as possible towards the pole. If, then, it is limited by a sinuous curve, as already explained, it is because circumstances of a purely physical nature oppose to it an insurmountable barrier.

A mean temperature of 46°.4, during summer, seems to be, for our continent, the only indispensable condition for the cultivation of barley; in the islands of the Atlantic Ocean, a summer temperature of three or four degrees higher appears to be necessary for its success. Ireland, indeed, where this grain cannot be cultivated, presents in its southern districts, at Ballaxik, a mean temperature of 57°.4 for the year,—4°· for winter, and 49°.4 for summer. It appears that here unseasonable rains are the means of preventing all cultivation of barley, which requires, for its success, a dry summer. In all cultivation is of most importance, varies between 46°.4 and 49° of mean temperature, during summer. In the continental regions 46°.4 is sufficient; but in the islands the excessive humidity requires to be compensated by a little extra heat in summer. Barley is cultivated as an alimentary plant as far as to the northern limit of rye or oats. Farther south it loses its importance, and is very little cultivated. Between the tropics this cereal does not succeed in the plains, because it suffers from heat more than any other of the cultivated grasses.

OATS (*Avena sativa*) is cultivated extensively in Scotland, to the extreme north point, in lat. 58° 40′. In Norway its culture extends to lat. 65°; in Sweden to lat. 63° 30′. In Russia, on the eastern limits appear to correspond with those of rye. Whilst in general oats is cultivated for the feeding of horses, in Scotland and in Lancashire, it forms a considerable portion of the usual food of the people. This is also the case in some countries of Germany, especially in the south of Westphalia, where the inhabitants of the "Sauerlands" live on oaten bread. South of the parallel of Paris oats is little cultivated; in Spain and Portugal it is scarcely known; yet it is cultivated with considerable advantage in Bengal to the parallel of lat. 25° N.

RYE (*Secale cereale*) is cultivated in Scandinavia, on the western side to the parallel of lat. 67° N. and on the eastern side to lat. 65° or 66° N. In Russia the polar limit of rye is indicated by the parallel of the city of Jarensk, in the government of Wologda, lat. 62° 30′. In Great Britain rye is scarcely cultivated at all, on account of the perfection of agriculture in these islands. It is only, indeed, in countries where the soil is little manured, and where the system of fallow is in use, that rye is a profitable culture. Thus it is as common in Russia, Germany, and some parts of France, as it is rare in the British Islands. Rye bread still forms the principal sustenance of at least one-third of the population of Europe; it is the characteristic grain of middle and northern Europe; in the north countries it is scarcely appreciated.

WHEAT (*Triticum*.)—Under this name are comprised an immense number of species produced during a cultivation of many centuries.

Two principal varieties are usually recognised, viz., *Triticum æstivum*, and *Triticum hibernum*, summer and winter wheat, the limits of which, both polar and equatorial, must differ somewhat; but this difference is not ascertained, because travellers, and even botanists, seldom allude to the distinction. Wheat is cultivated in Scotland to the vicinity of Inverness (lat. 58°), in Norway to Drontheim (lat. 64°); in Sweden to the parallel of lat. 62°; in Western Russia to the environs of St. Petersburg (lat. 60° 15′); while in Central Russia the polar limits of cultivation appear to coincide with the parallel of 59° or 60°. Wheat is here almost an exclusive cultivation, especially in a zone which is limited between the latitude of Tchernigov, lat. 54°, and Esutherinoslav, lat. 48°.

In America the polar limits of wheat are not known, on account of the absence of cultivation in the northern regions.

The physical conditions of these limits are, in the different countries where cultivation has been carried to the utmost extent, as follow:—

Countries.	Latitude.	Mean Temperature. Year.	Winter.	Summer.
Scotland (Inverness),	58°	46°	39°	57°
Norway (Drontheim),	64	40	28	59
Sweden,	62	39	25	60
West Russia (St. Petersburg),	60 15′	39	16	63

This table shows how little influence winter cold has in arresting the progress of agriculture towards the north; and this is confirmed by the interior of Russia, where Moscow is much within the limits of wheat, although its mean winter temperature is (according to Schouw) 55°.2. The spring-sown wheat escapes the cold of winter, and that sown in autumn is protected during winter by a thick covering of snow. The farther we advance to the north, the more deep and enduring is this covering. The temperature of the spring during the severe season, can therefore have no direct action on plants which are annual, or at least herbaceous, and buried under the snow.

The isothermal curve of 57°.2, which appears to be the minimum temperature requisite for the cultivation of wheat, passes, through the uninhabited regions of America, through the islands of Canada.

At Cumberland House, which is situated in the middle of the continent of North America, in lat. 54° N., long. 102° 20′ W., the officers of the Hudson Bay Company have established a prosperous agriculture. Captain Franklin found fields of barley, wheat, and even maize (*Indian corn*), growing here, most extraordinary severity of the winter.

The polar limits of the cultivation of wheat are the most important, since, during a part of their course, they coincide with the northern limits of those fruit trees which yield cider; and in some parts also with the limits of the oak. Agriculture and forests, therefore, both undergo a sudden and remarkable change at the approximate, on approaching the isotherm of 57°.2.

In Middle and Western Europe, wheat (*Triticum vulgare*) is cultivated chiefly in the zone between lat. 36° and 50°; farther north, rye (*Secale cereale*) is generally preferred. To the south of this zone, new combinations of heat, with humidity, and the addition of many other cultures, sensibly diminish the importance of this precious cereal.

The isocheimal curve of 68° or 69°, which appears to be the extreme limit of the possible cultivation of wheat towards the equator, oscillates between lat. 29° and 32°.

The cultivation of wheat is very productive in Chile and in the United States of Rio de la Plata. On the plateau of Southern Peru Meyen saw most luxurious crops of wheat, at a height of 8,500 feet, and at the foot of the volcano of Arequipa at a height of 10,600 feet. Near the lake of Titicaca (12,795 feet high), where a constant spring heat prevails, wheat and rye do not ripen, because the necessary summer heat is wanting; but Meyen saw oats ripen in the vicinity of Cuzada.

RICE (*Oryza sativa*) has been cultivated from all antiquity in the southern regions of Asia, of which it is doubtless a native, although it has not been found in a wild state.[6] It yields such a quantity of farinaceous matter that it would be cultivated everywhere if two conditions, rarely united, humidity and heat, were not indispensable to its growth. A summer temperature of at least 75°.4, with a great abundance of water, are found combined only in a few countries, between the equator and lat. 45°.

Rice constitutes the basis of the nourishment of the Japanese, the Chinese, of different people of India, and the neighbouring islands (at least near the rivers), of the Negroes of Madagascar, of those of the coasts of Mozambique and of Guinea, as well as of the inhabitants of Louisiana, in the United States of North America, not to mention other less extensive countries. It is perhaps the plant which nourishes the greatest number of men, and one of those which, in a given surface of ground, procures the greatest quantity of nutritive matter. In proportion to the weight of grain, the quantity of fecula it contains is greater than that in wheat, potatoes, or maize; and consequently, it is better adapted for exportation. This circumstance, together with the specialty of the requisite physical conditions, limits the culture of rice to the districts which are most favourable to it, and renders it universal, even exclusive, within the extent of these districts.

MILLET AND SORGHUM.—Different grasses of the genera *Holcus* and *Panicum*, enter into the agriculture of countries situated to the south of lat. 45° and 47° N. They even furnish to some populations an exclusive, though little valuable, nourishment. The penantry of Brittany subsist principally on buck-wheat (*Polygonum fagopyrum*), and the grain of *Panicum miliaceum*, of which they make a bouillie. In Italy, especially in Tuscany, the peasants make great use of Sorgho (*Holcus sorgum*.) In Africa and India, these sorts of cereals, though little productive, are generally cultivated.

BUCK-WHEAT (*Polygonum fagopyrum*.)—This plant, which grows to a height of about thirty inches, is extensively cultivated over a great part of Northern Europe, as well as in Brittany, in Siberia, and on the table-lands of Central Asia. It is understood to be a native of Asia, and to have been imported into Europe in the fifteenth century. The seeds of the buck-wheat are in some countries used as food, the meal being mixed with a portion of wheaten flour, of which a coarse bread is made. It is also used by the distillers at Dantzic in the manufacture of cordials; but it is chiefly cultivated as a green fodder.

DATE TREE.—The date (*Phœnix dactylifera*), of the family of palms, a native of Northern Africa, yields one of the most nourishing fruits in existence. It grows spontaneously, in great quantities, on the southern slopes of Mount Atlas, whence the name of the country of datea, which the Arabs give to a zone enclosed between this chain of mountains and the desert. It requires a dry warm climate; yet it is cultivated on the whole of the African coast of the Mediterranean, on the banks of the Nile, and in the Canary Islands—countries in which the drought is not so great as in the interior of Africa. It is found also in Senaar, Arabia, on the shores of the Persian Gulf, &c. Each tree yields annually from 150 to 200 pounds weight of fruit.

[1] Grundzüge der Pflanzengeographie, mit ausführlichen Untersuchungen über das Vaterland, den Anbau, und den Nutzen der vorzüglichsten Kulturpflanzen. Von F. J. F. Meyen. Berlin, 1836.

[2] Distribution Géographique des Plantes alimentaires, par M. Alphonse Decandolle, in the Bibliothèque universelle de Genève, nouv. série, t. ii., pp. 225-260; t. iii. pp. 1-26.

[3] See notes to the preceding plate, No. 1. of this division, and Meteorological division, plate I.

[4] The farmers of Picardy provided the table of Philip Augustus with wine; the extensive valley of Gloucester (lat. 51° 55′), was a great connected vine garden; and the Wahalang near Thorn, supplied the German knights who established it, with wine for the mess and for their revels.—*Berghaus Länder und Völkerkunde*, iii. 164.

[5] The word *grain* is applied generally to those grasses which serve for the ailment both of men and cattle. Of late they have been denominated *cereals*, but this name properly belongs to agriculture. The word *grain* is still the term used in commerce.

[6] Roxburgh (Flor. Ind., ii. p. 201) thinks he found it in the province of the Circars, on the shores of Ishore; but Wallich makes no mention of it, and Decandolle doubts the accuracy of the discovery.

NOTE.

To ascertain the possibility of cultivating certain plants, a knowledge of the mean temperature of the summer and winter months is indispensable. It is for example proved, that the northern limit of the cultivation of Barley, coincides with the summer temperature of 45° to 50° F. for this reason the author has attempted to delineate the curves of the mean temperature of both seasons in the Northern Hemisphere, although the observations from which they have been derived are not very numerous.

SURVEY

OF THE GEOGRAPHICAL DISTRIBUTION AND CULTIVATION

of the most

IMPORTANT PLANTS

WHICH ARE USED AS FOOD FOR MAN:

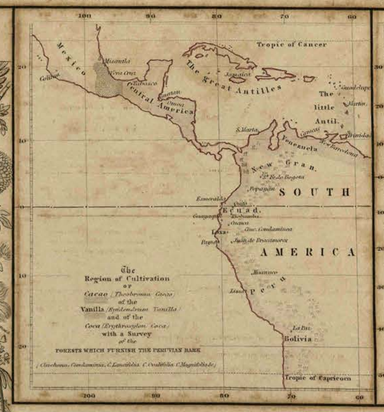
with indications of the

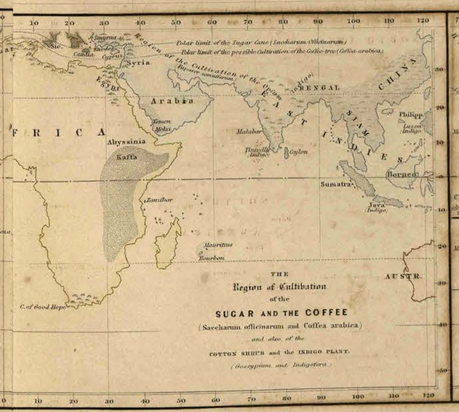
ISOTHERES & ISOCHIMENES.

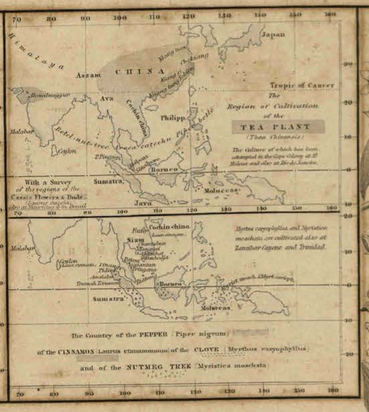
OR LINES OF EQUAL SUMMER & EQUAL WINTER TEMPERATURE.

BY PROFESSOR BERGHAUS, BERLIN.

Representation of the FORM of PLANTS cultivated in the TORRID ZONE.




AFRICA
Tropic of Cancer
Arabia
Abyssinia
Kaffa
Sumatra
Borneo
Java
Philipp. Isl.
THE Region of Cultivation of the SUGAR AND THE COFFEE (Saccharum officinarum and Coffea arabica) and also of the COTTON SHRUB and the INDIGO PLANT. (Asclepias and Indigofera.)



Explanations of the Colours used in large Map.

Wheat.	Rice	Maize	Barley	Rye & Wheat	Rye, Barley & Wheat	Wheat, Barley & Oats	Wheat & Maize	Barley, Oats & Rye	Wheat & Rice	Rice & Maize	Maize & Rye
1	10	6	3	2	8	5	7	4	11	12	9

William Blackwood & Sons, Edinburgh & London

Engraved by W. & A.K. Johnston

BANANA TREE.—The bananas (*Musa sapientum et paradisiaca*), of the family of the Musaceæ, appear to be natives of the southern portion of the Asiatic continent.[1] Transplanted at an unknown epoch, into the Indian Archipelago and Africa, they have spread also into the New World, and in general into all intertropical countries, sometimes before the arrival of Europeans.

The banana is a sweet fruit, which yields a great amount of nutritive substance. According to Humboldt, it affords, *in a given extent of ground*, forty-four times more nutritive matter than the potatoe, and 133 times more than wheat.[2] *Musa paradisiaca* is cultivated in Syria, to lat. 34°. Humboldt says it ceases to yield fruit at a height of 3,600 feet, where the mean annual temperature is 68°, and where probably the heat of summer is deficient.

COCOA NUT TREE.—The fine palm which we call the cocoa (*Cocos nucifera*), is a native of Southern Asia. It is spread, by cultivation, through almost all the intertropical regions of the Old and New Worlds; but it is cultivated nowhere so abundantly as in the Island of Ceylon, and those of Sumatra, Java, &c. On the shores of the Red Sea it advances to Mokha, according to Nicbuhr; but it does not succeed in Egypt. It is cultivated in the lower and southern portions of the Asiatic Continent, as on the coasts of Coromandel and Malabar, and around Calcutta. In the Island of Ceylon, where the fruit of this tree forms one of the principal aliments of the aborigines, the nuts are produced in such quantities, that in one year 2,977,375 were exported.[3] According to Marshall, it requires a mean temperature of 72°. Its northern limit, therefore, is nearly the same as the southern limit of our cereals.

BREAD FRUIT TREE.—The bread fruit tree (*Artocarpus incisa*), of the family of the Urticaceæ, is a native of the South Sea Islands, near the equator. It is distributed generally among the Friendly, the Society, and the Caroline Islands. The fruit is eaten either raw or cooked, and prepared in a variety of ways. It yields a considerable quantity of nutritive matter, although not so much as the banana. Unfortunately this tree does not succeed in the temperate zone, where it attains to lat. 32° or 33°. It has been imported into the Mauritius, the mean temperature of which is 78°.8 on the coast, and where the variation between the warmest and coldest months is only 10° or 12°.8. It has also been introduced into the Antilles and Brazil, where, at Rio de Janeiro, the coldest month has a temperature of 67°, and the hottest 81°. It was introduced into Cayenne in the vessel which transported the unfortunate victims of the eighth Fructidor.

BATATAS.—The batatas, or cassate (of the Spanish colonies), *Convolvulus batatas, L. Batatas edulis* Choisi, is cultivated generally in all intertropical regions, for the sake of its roots, and as a legume in temperate countries. In the south of the United States of America, the culture ceases in Carolina, under lat. 36°; in Portugal and Spain it reaches to lat. 40° and 42°, and as a legume, its cultivation is attempted to the vicinity of Paris. The native country of this plant is India; its bulbs are very similar to the potatoe, but have a sweeter taste, whence they have been called sweet potatoes; but it must not be confounded with the topinambur (*Helianthus tuberosus*), which is less cultivated, nor with the potatoe, which, in many localities, has usurped its name.

SPECIES WHICH HAVE THEIR ORIGIN IN THE NEW WORLD.

MAIZE (*Zea Mais*), Turkish wheat.—The origin of this plant has long been disputed.[4] In the equatorial countries of America maize is cultivated, according to Humboldt, at an elevation of 7,600 feet. In Europe, when cultivated in the open fields and for its grain, not as green fodder, its northern limits extend to lat. 47°. It is cultivated in abundance between Le Mans and La Flèche (lat. 48°) for feeding fowls. From this the limit is traced with some difficulty, around Paris to Frankfort-on-the-Maine (lat. 50, 30'). Its limits east of the Rhine are not ascertained. In the Plains of Brandenburg, (lat. 52° 30'), it yields abundantly, but is little cultivated, and that only for fodder. In Eastern Europe it occurs on the banks of the Dniester, lat. 49°; beyond this its limits are unknown.

Maize is an annual plant, which only requires heat in summer, and is not influenced by the cold of winter. In North America maize is cultivated more extensively than in Europe; in the interior of Canada its northern limits reach the parallel of lat. 50°. The highest point at which it has been cultivated in Europe is the village of Lescaux, in the department of Basses-Pyrénées, situated 3,280 feet above the level of the sea. This is above the limits of the vine, which only reaches 2,620 feet.

CHENOPODIUM QUINOA (*Solomon tuberosum*) was generally cultivated in America at the time of its discovery; but it is only a few years since its native country has been ascertained with certainty. Humboldt sought for it in vain, in the mountains of Peru and New Granada,[5] where it is cultivated in common with *Chenopodium Quinoa*. Before his time, the Spanish botanists Ruiz and Pavon were said to have discovered it in the mountains of Chili, on the coast of Peru. This fact doubled after the journey of Humboldt and Bonpland, but it was re-asserted by Caldelench, who sent spontaneous plants from Chile to the Horticultural Society of London; and latterly Mr. Cruickshanks confirmed it in a letter to Mr. Hooker,[6] in which he says, "This wild potatoe is very common at Valparaiso; it grows chiefly on the hills near the sea. It is also found in mountainous districts far from the sea, but never in the immediate vicinity of fields and gardens." There is little doubt, therefore, that Chile is the native country of the potatoe; but Meyen affirms, that he found it in a wild state, not only in the mountains of Chile, but also in the Cordilleras of Peru. It is probable that Sir Richard Hawkins introduced the potatoe into Europe in 1573; but this is very doubtful, since it has been also ascribed to Sir John Hawkins, in 1563; it is, however, certain, that Raleigh brought it from Virginia to England in 1586; and it appears probable, from the learned researches of M. Dunal,[7] that the Spaniards had established its cultivation in Europe before this time. It was first cultivated extensively in Belgium in 1590, in Ireland in 1610, and in Lancashire in 1684. It is not much more than a century since it was known in Germany. Between 1714 and 1724, it was introduced into Swabia, Alsace, and the Palatinate; in 1717 it was brought to Saxony; it was first cultivated in Scotland in 1728; in Switzerland, in the canton Berne, in 1730; in reached Prussia in 1738, and Tuscany in 1767. It spread slowly in France, till Parmentier, in the middle of last century, gave it so great an impulse, that it was contemplated to give his name to the plant; the famine in 1793 did still more to extend its cultivation.

According to Humboldt, the potatoe is generally cultivated in the Andes, at an elevation of from 9,800 to 13,000 feet; which is nearly the same elevation to which barley ascends, and does not grow higher than wheat. In the Swiss Alps of the canton Berne, the potatoe reaches, according to Kastoffer, an elevation of 4,800 feet.

Towards the north of Europe, the potatoe extends beyond the limit of barley, and consequently that all the cereals; but a peculiar variety has been introduced into Iceland, where barley will not grow. The potatoe degenerates rapidly in warm countries; yet the English have succeeded in cultivating it in the mountainous regions of India; but it is doubtful if it will ever succeed in the intertropical plains of Africa and America, where the temperature varies less than in Bengal. An elevation of at least 4,000 feet seems to be necessary for the growth of the potatoe in the equinoctial regions.

MANIOC.—The *Jatropha Manihot*, or *Janipha Manihot*, of the family of the Euphorbiaceæ, is a shrub, the fleshy roots of which yield a considerable quantity of farina, known under the name of manioc or cassava. There are two kinds, a sweet and a bitter, called in Spanish America, juca dulce and juca amarga. The root of the *Jatropha Aipi Pohl*, is perfectly innocuous; but that of *Jatropha Manihot Janipha*, contains a white sharp juice, which is an active poison; but its deleterious effects are removed by repeated culture, or by simple pressure.

The manioc is a native of Brazil, and is cultivated in America, on both sides of the equator, to about lat. 30° N. and S. It is the principal, if not the only kind of musl used in Brazil, at least in the north, near the equator. An acre of manioc is said to yield as much nutriment as six acres of wheat. Meyen says: "It is not possible sufficiently to praise the bountiful manioc plant." The Indians find in this a compensation for the rice and other cerealia of the Old World.

ARROW ROOT.—The arrow root (*Maranta arundinacea*) is originally from South America, but has long formed the object of extensive cultivation in the West Indies, whence it has been introduced, with the best effects, into Ceylon. The fecula which abounds in the root of this plant, forms a delicate and nourishing article of food. Its name is derived from the property it is said to possess of being an antidote to the poisoned arrows of the Indians.

GEOGRAPHICAL DISTRIBUTION AND CULTIVATION OF THE SUGAR CANE, TEA AND COFFEE PLANTS, SPICES, &c.

(See the small Maps at the foot of the Plate.)

SUGAR.—The sugar cane (*Saccharum officinarum*) belongs properly to the torrid zone, but Humboldt remarks, that although it succeeds best with a mean temperature of 76° or 77°, yet it may be cultivated with advantage in every place where the mean temperature of the year is not below 67° or 68°. It grows on the plateau of Neyuni, to a height of 4,800 feet; and in New Granada the produce of part of the sugar is grown on the Cordillera at a height of from 5,300 to 5,100 feet above the level of the sea.

Sugar was cultivated in modern Europe before the time of the Crusades; and it has been imported by Venetian vessels from Alexandria and the other ports of the Levant since the earliest times.

When the Arabians gained a footing in the Iberian peninsula, they introduced the cultivation of the sugar cane, first in Valencia, then in Granada and Murcia, which are situated between the southern limit of 64° and 67°. Sugar is still cultivated there, but on so small a scale, as not to be of commercial importance. At the time of the discovery of the country by Columbus, it was introduced by the Spaniards into the Canary Islands and Madeira. The plant was found growing in a wild state in many parts of America, at the time of the discovery of the country by Columbus; and it has flourished on the coasts of China, since the commencement of the Christian æra. Barbadoes came into the possession of England in 1627, and in 1646 the cultivation of the sugar cane was commenced. In 1656, when Jamaica was conquered by the English, it contained only three small sugar plantations; but the rapid increase of English settlers from Barbadoes and the mother country, soon brought this cultivation into prosperity. West India sugar was first cultivated in the Island of Hayti or St. Domingo, where, in 1518, the Spaniards had twenty-eight sugar presses in operation; this island was also for many years the principal purveyor of sugar for the European market. The range of the sugar cane may be said to extend to all the regions of the torrid zone, and beyond its limits to those countries the mean temperature of which is not less than 64°; the productions of certain districts, however, are of special importance for the supply of Europe. These are, in the New World, the West Indian Islands, Guiana, and Brazil; in the Old World, Mauritius, Bourbon, Bengal, Siam, Java, the Philippine Islands, and China. In Bengal, the chief cultivation is carried on in the Zemindary of Pedpoor along the banks of the Elisezan river, and at Benares. The produce of Louisiana is almost entirely consumed in the continent of America.

In 1833 the amount of sugar produced was calculated at upwards of 610,000 tons, of which fourfifths were furnished by the New, and one-fifth by the Old World.

From the interesting inquiries of Humboldt, it appears that the consumption of sugar in different countries, was, in 1826, according to the following proportions:—the Island of Cuba, 52; Great Britain, 21; United States of North America, 8; France, 3; that is to say, every individual in these countries consumed annually the given number of pounds weight of sugar. More recently, M'Culloch reckons the annual consumption for France at six pounds weight per head; which is about a fourth part of the amount consumed by each individual in Britain.

COFFEE.—The coffee bush or tree (*Coffea Arabica*, Linn.) is a native of the Ethiopian highlands of Africa, whence it was introduced into Arabia at the end of the fifteenth century.[1] This country, renowned since the time of Solomon, under the name of Arabia Felix, is no less celebrated in modern times, as the first coffee-garden of the East. Here, that beverage, which is now extended to every civilized country in the world, and which has grown to be one of the most important objects of commerce, appears to have been first introduced. In little more than a century, this plant spread to Java and Manila, and thence, by Ceylon and the Isle of Bourbon, to the West Indies, Surinam, Cayenne, and Brazil. In these new fields hundreds of thousands of labourers of all kinds are engaged in its cultivation. Its produce is more than 300,000,000 pounds of coffee-beans, in the transport of which, through the Indian and Atlantic Oceans, more than 160,000 tons of shipping are annually employed.[2] The coffee plant succeeds best in the hottest regions of the tropics; but the artificial limit of its cultivation extends, on the west to lat. 36° N., where the mean temperature is only 67° and 68°. Between the tropics, it grows best at an elevation of between 1,200 and 3,200 feet, but it seldom extends beyond 6,400 feet. Its cultivation has of late greatly increased in Brazil, and it is rapidly extending in Mysore, India, especially on the coast of Malabar, and in the Island of Ceylon. Coffee was not known in Europe till several centuries after the introduction of sugar. The first coffee-house in England was opened in London in 1652; and the first in France, at Marseilles in 1671.

TEA.—The tea plant (*Thea Chinensis*) which, next to sugar and coffee, forms one of the most important articles of consumeve, is an evergreen shrub, growing to a height of five or six feet. It is indigenous in China, Japan, and Upper Assam. Its distribution extends from the equator to lat. 45° N.; here it grows in the open air, while in higher latitudes it can be reared only in the green-house.[3] It is cultivated in the gardens of Java, Singapore, Malacca, and Penang, all which places are situated within 6° of the equator; but, judging from its cultivation in China, it appears to be most successful between the parallels of lat. 25° and 35° N., with a mean annual temperature of from 61° to 73°. The tea of commerce is cultivated exclusively in China, and there it is limited to portions of the provinces of Fokien, Quantung, Kiang-nan, Kiang-si, and Chekiang; of which Fokien furnishes the greatest quantity of black, and Kiang-nan the greatest amount of green tea.[4] The principal tea districts are between the above named parallels and the meridians of long. 115° and 122° E.; but almost every province of China produces a small quantity of tea, which, however, is of inferior quality, and is consumed in the country. The tea plant is cultivated on an extensive scale also in Japan, Tonquin, and Cochin China, as well as in some of the mountainous districts of Ava. It has recently been discovered in a wild state in the province of Upper Assam, where its culture is proceeding satisfactorily.[5]

From the successful cultivation of this important plant in the north-western provinces of India, there is little reason to doubt that the English will soon be able to compete with the Chinese in its production, and thus deprive them of the monopoly they have so long held.[6]

The propagation of this plant presents great difficulties; yet the Dutch have succeeded, with the assistance of Chinese cultivators from Fokien, in producing on the hilly regions of Java, a better article than might have been expected from the heat of the climate. Numerous attempts have been made in Brazil, also with the assistance of Chinese growers, and they have succeeded in producing a small quantity of a fair quality; but the expense of cultivation is so great, as to render it improbable that it can be prosecuted with advantage. It has long been considered practicable to cultivate tea in Europe, and the experiments which have been made appear to have confirmed the fact. The attempts to introduce it into Algeria have uniformly failed, from excessive heat.

Tea was first imported into Europe by the Dutch, in 1610, and it was brought to England in 1666. The consumption of tea in Great Britain was, in 1830, 30,000,000 of pounds weight, while in the whole United world it was only about 22,000,000 pounds. The annual consumpt in Great Britain is now (1848) reckoned at from 40 to 50 millions of pounds weight.

PARAGUAY TEA.—The species of Holly (*Ilex Paraguensis*), which grows spontaneously in the forest regions of Paraguay, yields the celebrated beverage called Maté, in Brazil. The leaf of this plant is from four to five inches long; when prepared for use as tea, it is reduced to powder, and hence the decoction must be quaffed by means of a tube with a bulb perforated with small holes.

CACAO.—The Cacao tree (*Theobroma cacao*) grows spontaneously in several countries of the torrid zone of America, especially in Guiana, Mexico, and on the coast of Caraccas, under a mean temperature, fluctuating between 75° and 84°. The fruit of this tree is a large pulpy capsule, having somewhat the form of a cucumber, the seeds of which furnish the buttery, slightly bitter substance called cacao or cocoa, from which chocolate is prepared. According to Humboldt, the cacao tree was extensively cultivated in Mexico, in the time of Montezuma (1520). Here the Spaniards became acquainted with its qualities, and introduced it into the Philippine Islands. And the Philippine Islands, and the Spanish colonies, chocolate was considered not as a luxury, but as a necessary article of sustenance. It forms a wholesome and very nourishing aliment, especially valuable to the traveller. It is now cultivated chiefly in Central America, and in Brazil, where it is said to be of excellent quality, and to great abundance. Nicaragua, on the banks of the river Magdalena (lat. 9° and) in British, French, and Dutch Guiana. Very little of the produce of Peru is sent to Europe; part of that grown in Chile is used in the South Sea Islands, India, and Japan. In the West India Islands the cultivation of cacao has given place, to a great extent, to that of sugar and coffee.

VANILLA.—The *Epidendrum vanilla*, or *Vanilla aromatica*, is a native of Tropical America; it grows wild in all places where heat, shade, and moisture prevail. All the vanilla which is used in Europe is imported from Mexico, where it is gathered in the states of Vera Cruz and Oaxaca, on the eastern slopes of the Cordillera of Anahuac, between the parallels of 20° and 22° N. The delightful aromatic is used in the manufacture of various liqueurs, chocolate, confections, and perfumery.

COCA.—This shrub (*Erythroxylon coca*), which grows in the mountainous districts of Peru and Chile, is to the natives of these countries what opium and betel are to the natives of Southern Asia. Its leaves, when dried and pulverized by the Indians, have such an influence in allaying hunger and thirst, that those who use them subsist for several days without any other nourishment. Coca is used extensively by the miners of Peru, and has all the deleterious effects of opium.

PERUVIAN BARK.—As a contrast to the deleterious coca, we have here indicated the forests which produce the cinchona, or Peruvian bark, the discovery of the Rubiaceæ. Many of these are *Cinchona floribundia, C. Lancifolia, C. Oruifolia*, and *C. Magnifolia*. The uses of this valuable plant, unknown to the Indians, appear to have been first discovered by the Jesuits, and hence it is often called Jesuits' bark. It was introduced into Europe in 1632, but was not extensively used as a medical remedy till the latter part of the seventeenth century.

PEPPER.—Almost all the plants of the family Piperaceæ have a strong aromatic smell, and a sharp burning taste. This small group of plants is confined to the hottest regions of the globe; being most abundant in Tropical America, and in the East Indian Archipelago, but rare in the equinoctial regions of Africa. The *Piper nigrum*, or pepper plant, represents the whole property of the order, which is not confined to the fruit, but pervades, more or less, the whole plant. It is peculiar to the torrid zone of Asia, and appears to be indigenous to the coast of Malabar, where it has been found in a wild state. From this, it extends between the meridians of long. 96° and 116° E., and the parallels of lat. 5° S. and 2° N., in which space its pepper is found. Within these limits are the coasts of Sumatra and Borneo, with the Malay peninsula and part of Siam. Sumatra produces by far the greatest quantity of pepper. In 1842, the annual produce of this island was reckoned at 30,000,000 pounds, being more than the entire produce of all the other pepper districts in the world.

CINNAMON.—The cinnamon tree (*Laurus cinnamomum*), is a species of laurel which, in a natural state, attains a height of from twenty to thirty feet; it grows only in the south-west portion of Ceylon, and in Cochin China. The inner bark of this tree furnishes one of the most valuable spices.

CLOVES.—The clove tree (*Myrtus Caryophyllus*) has the appearance of a pear tree, of from twenty to forty feet in height. It is a native of the Molucca Islands, and is cultivated chiefly at Amboyna. The spice called clove, resembles a short thick nail; hence its name, from the French word, *clou*.

NUTMEG.—The nutmeg tree (*Myristica moschata*) is a native of several islands of the Eastern Archipelago, but its cultivation is exclusively confined almost to the Banda Islands. This tree grows to a height of about thirty feet. The fruit resembles a small peach, both in shape and colour; and the thin membraneous substance which covers the nut forms the spice, known in commerce under the name of mace.

ARROWROOT.—This important article of commerce is the hairy covering of the seeds of several species of Gossypium, of the family of the Malvaceæ. It grows spontaneously in almost all the countries within the torrid zone of Asia, Africa, and America, and is cultivated extensively in many countries beyond these limits. The planters recognise an infinite number of species of the cotton plant, of which the following are the principal:—1st, Herbaceous cotton. 2d, Shrub cotton. 3d, Arborescent cotton. The first, and most valuable, is an annual plant, which grows to a height of eighteen inches or two feet, and is cultivated extensively in the United States, China, &c. The second is found in nearly all the countries where the first occurs; it is biennial or triennial, according to climate. The third grows in India, China, and in the interior, and on the west coast of Africa, as well as in some parts of America. It nearly resembles the shrub cotton, except in its greater size. The manufacture of cotton cloth has existed in India from the remotest antiquity. Cotton vestments are mentioned by Herodotus in the year 445, B.C., and the Romans had brought its fabrication to a high degree of perfection, at the date of the discovery of America.

CASSIA, is the produce of a species of laurel (*Laurus cassia*), nearly allied to *L. cinnamomum*, and is a native of the islands of the Eastern Archipelago, the Philippine Islands, and part of the eastern coast of China.

INDIGO.—This valuable dye is extracted from the leaves and small branches of several leguminous plants, of which the two principal varieties are *Indigofera tinctoria* and *I. anil*, the first being cultivated in Asia, and the second in America. The manufacture of indigo has been practised in India from time immemorial, but only to the end of the sixteenth century, the plant which produces it was unknown in England. It has since been introduced into the West India Islands, Guatemala, Brazil, &c.

[1] Robert Brown, Bot. of Congo, p. 51.

[2] These figures must be considered as only approximative, since nothing is more difficult than to estimate the nutritive qualities of different aliments.

[3] Marshall in Mem. Wernerian Nat. of Hist., v. p. 362.

[4] It was understood to be a native of America, about M. A. De Saint Hilaire found it wild in the primitive forests of Brazil; but M. Bonafous, in a recent work (Paris, 1836), claims for it an Asiatic origin.

[5] Essai sur la Géogr. des Plantes, p. 26.

[6] Hooker, Botan. Miscell., xi., p. 204.

[7] Hist. des Solanées.

[1] C. Ritter shows that in tropical Africa, where the plant receives scarcely any culture, it yet, in many places, forms thick woods, and yields excellent fruit; and he draws an argument for this being its native country, from the identity of its name with that of the district of Kaffa, where it is indigenous, viz., Kaffa, while the word has no affinity with the Arabic language. See a complete essay on the coffee tree, in that part of his great work entitled, "Die geographische Verbreitung einiger culturverbreitender Nutzpflanzen Afrikas," Berlin, 1847.

[2] Ib. p. 4.

[3] According to Mr. Ball, "On the Cultivation of Tea in China." It is a hardy plant, and exhibits great power of adaptation to climate, extending over the vast space of 25° of lat., and 30° of long.

[4] The different kinds of green and black tea are made from the leaves of one species of plant, collected at different periods of their development. From a chemical analysis by Mr. Warrington, it appears that the colouring matter used in the preparation of green tea consists, chiefly, of Prussian blue and gypsum.

[5] The first parcel of Assam tea was transmitted to England in 1838. The black was reported to be good, but "the green had a vile taste, from some failure in the manufacture."

[6] From the report of Dr. W. Jameson, February 1847, it appears that the tea grown in the valley of the Dhoon has been pronounced equal to China tea of a superior class; and that in the provinces of Kemaon and Gurh-wal, 476 acres, containing not fewer than 392,379 plants, were under cultivation. "The crop is thriving in different places, over 4° of lat, and 3° of long, and 100,000 acres are now available in the Dhoon alone, for the purposes of tea cultivation." See opinions of Dr Wallich and Professor Royle on the tea of India, in Transactions of Asiatic Society, 5th February 1848.—Athenæum, 1848, p. 253.

ZOOLOGICAL GEOGRAPHY.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION OF MAMMIFEROUS ANIMALS,

OF THE ORDERS:

QUADRUMANA, MARSUPIALIA, EDENTATA, AND PACHYDERMATA.

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GENERAL INTRODUCTION.

It has long been observed that certain tribes, genera, and species of animals, are peculiar to certain regions of the globe, and an investigation into the manner of their distribution, or an inquiry concerning the laws affecting their geographical arrangement, has ever been regarded as constituting, in itself, an interesting subject of research, and forming a necessary adjunct to a complete understanding of the nature and extent of the animal kingdom. The accomplishment of this, in so far as it is attainable in the present limited state of our knowledge of animal life, is the object of this division of the Physical Atlas. As, by comparing the flora of a particular country or district with that of an extensive zone or quarter of the earth, we are enabled to mark its peculiarities, and ascertain in how far it harmonises with the character of the entire vegetation; so we shall find, that by following a similar method in examining the fauna of a given district or zone, we are led to equally interesting results. By such researches modern science has established the singular and unexpected phenomenon of the division of the globe into different and distinct regions or nations of plants and animals. In some respects the distribution of animals resembles that of plants; the limits of both are, in so far, circumscribed by the intervention of seas, and continuous chains of mountains, yet both are chiefly influenced by the inequalities of temperature. Animal life is most intimately connected with, and dependent upon, the vegetable kingdom; heat and moisture stimulate the growth of plants, therefore the greater the amount of these atmospheric phenomena, so much more luxuriant is vegetation, and so much more abundant are animal formations. Hence we find, as a general rule, that vegetation is most exuberant, and animals most prolific, in the countries under the tropics, where heat is greatest, and moisture most abundant. As these decrease in a direction from the equator towards the poles, so, and perhaps in a similar proportion, do animals decrease, not only in the size of individuals, but also in the number of species. This law affects all animals, the vertebrated as well as the invertebrated, in so far as they are inhabitants of the land, but it is reversed in the case of those of higher organization which inhabit the sea; the latter (as explained in the notes to Map No. 2 of this division) being found to *increase* in a direction from the equator towards the poles.

We have here an interesting example of the connection and harmony that subsist between the different branches of natural science; we see the dependence of animal upon vegetable life, and of both on meteorology.

As animals, like plants, are adapted to particular climatic conditions, like them also they are subjected to invariable laws; for, though man can bear with equal impunity the burning heat of the tropics, or the intense cold of the frozen zone, yet he has not succeeded in rendering animals cosmopolite. Of all vertebrated animals, the dog alone is enabled to accompany man in all his migrations. Many others cannot exist except under the influence of a determinate climate; they pass not the limits which the Author of the universe has fixed as the bounds of their habitation. The polar bear could not live under the scorching rays of a vertical sun, nor could the lion or the tiger long survive the rigours of an arctic winter.

"Thus the apes which multiply in the tropical regions almost always die of phthisis, when exposed to the humidity of our climates; whilst the rein-deer, adapted by nature to support the long and severe winters of Lapland, suffers from the heat of St Petersburg, and sinks rapidly under the influence of a temperate climate. It results from this, that in a majority of cases the difference of climate is sufficient of itself to arrest the species in their progress from higher latitudes towards the equator, or from the equatorial regions towards the poles." Nor is this law confined, in its operation, to distant and dissimilar regions of the globe—we find it affecting the fauna of different parts of the same continent; thus Mr Lyell, in his recent travels in North America, observes there are "several distinct zones of indigenous Mammalia extending east and west on this continent, where there are no great natural boundaries running in the same direction, such as mountain ridges, deserts, or wide arms of the sea, to check the migrations of species. The climate alone has been sufficient to limit their range. The mammiferous fauna of New York, comprising about forty species, is distinct from that of the arctic region six hundred miles north of it, and described by Dr Richardson. It is equally distinct from that of South Carolina and Georgia, a territory about as far distant to the south."[1]

The difference between a coast and a continental climate is also exemplified in the decrease of vegetable and animal life in proportion as we recede from the coasts, and approach the interior of continents. In the arid plains of the interior, vegetation loses its luxuriance, and, consequently, its power to maintain the numerous tribes of animals which depend for subsistence on the leaves and plants peculiar to a humid soil.

The analogy between vegetable and animal geography is not less apparent when we consider the distribution of the latter in a perpendicular as well as in a horizontal direction. "The Himalaya, with a temperature varying from the heat of the equator to that of the poles, presents an epitome of the Mammalogy of the world—a succession of species similar to that which we meet in travelling from India to Kamtschatka, or from Brazil to Labrador. The *Thibetan Musk* is found on the mountains in the vicinity of the snow. The antelope *Ghoral*, *A. thar*, and *A. Hodgsonii*, peculiar to these mountains, are generally found on the most inaccessible places in the warm weather; but in the colder, like most other animals, they come down to lower elevations for the benefit of a milder climate and better pasturage."—"The *Pika*, like the *Arctomys*, lays up a winter store, and continues to thrive in a climate apparently incompatible with animal existence."[2]

The influence of temperature on the animal economy explains the reason why certain species remain shut up within a chain of mountains, without being able to spread themselves to similar localities in other mountainous districts. For as temperature decreases with the elevation of the soil, animals which live at considerable heights cannot descend into the plains, in order to arrive at other mountains, without traversing countries the temperature of which is much higher than that to which they are accustomed. The llama, for example, as Humboldt remarks, abounds in the pasture-lands of Peru and Chile, situated at an elevation of from 13,000 to 16,000 feet above the level of the sea, and extends thence to the extremity of Patagonia; but is not known either in Brazil or Mexico, because it could not arrive there without descending to regions too warm for its constitution. Many hypotheses have been advanced to account for the present distribution of animals over the surface of the globe; but on this subject we are not called upon to enter, and shall only remark, that there is abundant evidence, in the wonderful adaptation of the structure of animals to the circumstances in which they are placed, to convince even the most casual observer that this arrangement is the result of design, and that they have been so placed by the Author of the universe as a part of "the great symmetrical whole of creation."

Zoological Geography, then, is that part of our science which treats of the habitats, the limits of distribution and dispersion of animals as they at present exist, as well as the varieties of animal life considered in relation to external circumstances.

The field of view thus opened up to the inquirer is of vast, indeed almost boundless extent, when we consider that it may comprehend the whole animal world, which, according to the classifications of Cuvier and Oken, two of the greatest naturalists of the age, is divided, by the former into nineteen, and by the latter into thirteen classes or orders.

In the following table, which will serve as a guide to our Zoological Chartography, Cuvier's classification is inverted, in order to place it on a parallel with Oken's system:—

CUVIER (1829).	OKEN (1843).
A. Radiated Animals (*Animalia radiata*).	First Degree—Gelatinous Animals.
Class 19. Infusoria, Animalcules.	Class 1. Infusoria.
18. Polypi.	2. Polypi.
17. Acalephæ, Medusæ or sea-nettles.	3. Medusæ.
16. Entozoa, Intestinal Worms.	
15. Echinodermata, Sea-hedgehogs and Sea-stars.	
B. Articulated Animals (*A. articulata*).	Second Degree—Tentacious Animals.
Class 14. Insecta, Insects.	Class 4. Muscles.
13. Arachnides, Spiders.	5. Snails.
12. Crustacea, Marine animals with crustaceous envelope.	6. Barnacles, &c.
11. Annelides, Worms.	
C. Molluscous Animals (*A. Mollusca*).	Third Degree—Articulated Animals.
Class 10. Cirrhopoda, Barnacles.	Class 7. Worms.
9. Brachiopoda, Bivalve shells, &c.	8. Crabs.
8. Acephala, Muscles, &c.	9. Flies (true insects.)
7. Gasteropoda, Snails, Limpets, &c.	
6. Pteropoda, Theelia, &c.	
5. Cephalopoda, Cuttle-fishes.	
D. Vertebrated Animals (*A. Vertebrata*).	Fourth Degree—Vertebrated Animals.
Class 4. Pisces, cold-blooded Fishes.	Class 10. Fishes.
3. Reptilia, cold-blooded Reptiles.	11. Reptiles.
2. Aves, Birds with warm blood.	12. Birds.
1. Mammalia.	Fifth Degree—Sense Animals.
	Class 13. Mammalia, Hair Animals.

When we consider the foregoing classification of the distribution of animal life over the globe, it is evident that its chartographic treatment and representation has to contend with peculiar and very serious difficulties, occasioned chiefly by the great diversity of animals — the representation of which would require a vast number of maps. Hence, in this first attempt at chartographic zoology, and in our limited space, we can only give outlines of the geographical distribution of particular divisions of the animal world, with a view of calling attention to the interesting nature of the study of animal geography, and to stimulate to further researches and investigations those who are engaged in the pursuit of this branch of the physical description of the earth.

The occurrence of a class of animals in a particular country or region is indicated on the map by shading, which is darker in proportion to the number of species existing in it. Thus, for example, in the map of the Quadrumana, the shading indicates that the animals of this order inhabit the southern countries of Asia, nearly all Africa, and a great part of South America; while the depth of shading shows that they occur in greatest numbers in the tropical regions of those countries. Again, in the map of the Marsupialia, it is shown that no animals of this order occur in Asia or Africa, and that the greatest number of species is found in Australia.

Besides this general view of the distribution of animals, we have attempted to define, by means of coloured lines on the different maps, the limits of the most important and characteristic species of each of the different families and genera. This has been attended with difficulties which, in many cases, have proved insurmountable. In this respect, botanical has a great advantage over zoological chartography; rest is the characteristic of vegetable, while motion is the attribute of animal life. With comparative ease the botanist may examine the stations of plants, and ascertain the place where they cease to grow; but the case is very different with the zoologist, who has to pursue the fugitive animal, as circumstances may require, through field or forest, over the verdant meadow or through the dreary wilderness, and must be content to arrive at a knowledge of its habitat from indirect and often vague and unsatisfactory sources. It cannot be expected, therefore, that the boundaries marked on the map should strictly define the range of every particular animal; for that would be to demand from this method of representation an amount of information which, in the present state of our knowledge of animal life, it is impossible to attain.

Cuvier's classification forms generally the basis of these representations of zoological geography, except in cases where numerous discoveries since his time have rendered a different arrangement necessary, as in the case of the Marsupialia, of which our knowledge has been so greatly increased within a few years.

Animals which, without necessity or constraint, pair with each other, belong to a *species*, and those species which agree in the proper marks, form a *genus* (which, according to Oken, would be more properly designated a tribe); zoologists, however, are not agreed as to what the true marks consist in, and this leads to great uncertainty in the number of genera; but this is not the case with species, the fixing of which is definitely settled by nature.

Species, therefore, form the groundwork of accurate statistical researches concerning the geography of animals.

From these introductory general remarks, we now turn to the special explanation of the first map of this series which is devoted to a portion of the Mammalia. Animals of the higher organization claim our chief attention, and among these the first are the Mammalia, which, living on land, are most open to observation, and the knowledge of which is therefore most extended.

Cuvier divides the Mammalia into nine orders, the first of which, comprising man (Homo), is omitted in this enumeration:—

2. Quadrumana, Four-handed order, Apes.	6. Edentata, Toothless Animals.
3. Carnivora, Beasts of Prey.	7. Pachydermata, Thick-skinned Animals.
4. Marsupialia, Pouched Animals.	8. Ruminantia, Ruminating Animals.
5. Rodentia, Gnawing Animals.	9. Cetacea, Whales.

We have chosen the animals of the second, the fourth, the sixth, and the seventh order for the subjects of our first sheet. The second, contains the animals of the third and ninth orders—the *Carnivora* and the *Cetacea*. The third, those of the fifth and eighth orders—the *Rodentia* and *Ruminantia*. The fourth sheet is devoted to birds, and the fifth to amphibious animals and serpents.

In 1829, Winding reckoned the number of species of Mammalia at 1,930; Charles Bonaparte, in 1832, at only 1,142; but Oken is of opinion that the probable number may be assumed to be 1,500.

We have, therefore, taken this last as the basis of our calculations in ascertaining the proportionate numbers of the species.

DESCRIPTION OF THE MAP.

This sheet is divided into three compartments, comprising four maps of the geographical division and distribution of

1. Quadrumana, Four-handed Mammalia.
2. Marsupialia, Pouched Mammalia.
3. Edentata, Toothless Mammalia.
4. Pachydermata, Thick-skinned Mammalia.

Each compartment contains figures of some of the most important and characteristic animals as types of the orders represented on the map, and generally those belonging to the same quarter of the globe are placed together. All the typical animals are delineated according to accurate scale, so that the relative size of each figure, in comparison with others may be ascertained at a glance. This important element is generally overlooked in representations of the objects of natural history, in which the elephant and the mouse are often represented of an equal size. It is sometimes, difficult, however, to find a scale suitable at once for the animals to be represented and the space allotted for their delineation; hence, on this sheet two different scales have been adopted—the larger of which, namely that for the *Quadrumana*, *Marsupialia*, and *Edentata*, is equal so one-twentieth of nature, that is to say, the natural size of the animals is twenty times larger than they are represented on the plate. The

[1] Milne Edwards.
[2] Royle. Illustrations of the Botany and other branches of the Natural History of the Himalayan Mountains.
[1] Lyell's Travels in North America, vol. i., p. 172.

ZOOLOGICAL GEOGRAPHY

SHEET № 1

SIMIAE PLATYRRHINI MONKEYS OF THE NEW WORLD

	9 ser.	1/20 of all
	91 Spec.	Mammalia

I Sapajus (Sapajous) = 45 Spec.
II Saguins (Saguinins) = 48 Spec.

1 Mycetes (Howlers, howling apes)	8 sp.	1 Pithecia (Saki or Ear-, tails)	12 Sp.
2 Ateles (Spider Monkeys)	9 .	2 Callithrix (Squirrel Monkeys)	11 .
3 Lagothrix (Gigantic Monkeys)	2 .	3 Nyctithecus (Night-, Monkeys)	3 .
4 Cebus (Sapajous or Weepers)	23 .	4 Hapale (Ouistitis) (or Marmosets)	10 .
		5 Midas (Tamarins)	12 .

TYPES.

1 Mycetes seniculus (Cruizo Howler, Araguato)
2 Pithecia satanas (Black Ear-tuft, Guarin)
3 " melanocephala (Black-headed Ear-tuft Gacajao)
4 Nyctithecus trivirgatus, Aotus Humboldtii (Douroucouli)
5 Hapale jacchus (Pinche), or. Mormosset
6 Midas rosalia (Maribina, Silky Tamarin)
7 Midas leonina (Leonine Tamarin)

Perpendicular distribution.

1 Mycetes ruthmanus (Beelzebub)
2 Mycetes seniculus (Araguato)
3 Genus: Mycetes & Genus Howlers & Weepers
4 Hapale vulgaris (Pinche)
5 Genus: Pithecia (Ear-tufts)
6 Genus: Ateles (Spider Monkeys)
7 Genus: Callithrix (Squirrel Monkeys)
8 Genus: Midas (Tamarins

Scale - 20 of Nature

SIMIAE CATARRHINI MONKEYS OF THE OLD WORLD

	9 Gen.	1/10 of all
	72 Spec.	Mammalia

I Eubles Monkeys = 72 Spec.

1 Cynocephalus (Baboons)	22 Spec.	1 Rhinopithecus (Snub-nosed Monkeys)	4 Spec.
2 Inuus (Magots)	9 .	2 Semnopithecus (Entellus or Sacred Monkey)	12 .
3 Macacus (Macaques)	9 .		
4 Colobus (Thumbless apes)	6 .	PROSIMIAE (MAKIS) = 8 Gen.	1/2 of all Mam.
5 Cercopithecus (Guenons)	17 .	1 Lemur (Lemurs)	12 Spec.
6 Theropithecus (Gelada Baboons)	1 .	2 Lichanotus (Indris)	2 .
7 Semnopithecus (Sokkoos apes)	12 .	3 Stenops (Lorises)	4 .
		4 Otolicnus (Galagoes)	4 .
		5 Tarsius (Tarsiers)	6 .

TYPES.

1 Macacus radiatus (Toque Macaque Monkey)
2 Macacus cynomolgus (Crab-eating or Ceylonese Macaque)
3 Cercopithecus Mona (Mona or Spotted Monkey)
4 Semnopithecus Maurus (Budeng or Negro Entellus-ape)
5 Rhinopithecus Roxellanæ (Snub-nosed Monkey)
6 Nasalis larvatus (Red or Belatin Orang)
7 Simia satyrus (Red or Belatin Orang)

Perpendicular distribution.

1 Semnopithecus (Semnopithecus maurus)
2 Macacus cynomolgus (Macaque Monkey)
3 Cercopithecus Mona (Mona or Spotted Monkey)
4 Semnopithecus Maurus (Budeng or Negro Entellus-ape)
5 Rhinopithecus Roxellanæ (Snub-nosed Monkey)
6 Nasalis larvatus (Red or Belatin Orang)
7 Simia satyrus (Red or Belatin Orang)
8 Cynocephalus Porcarius (Common Baboon)

Scale - 20 of Nature

EDENTATA (TOOTHLESS ANIMALS)

	8 Genera	1/54 of all
	25 Species	Mammalia

New World = 20 Species

1 Bradypus (Ai, Arctopithecus or Ai, Apes)	Sloths	2 Spec.	5 Orycteropus (African Ant-eater)	1 Sp.
2 Dasypus (Armadillos or Cheloepus (Unau))	"	7 .	6 Manis (Pangolins)	4 .
3 Dasypus	Armadillos	M .	7 Echidna or Tachyglossus (Porcupine Ant-eater)	2 .
4 Glossophaga (Tamandua)		1 .	8 Ornithorynchus	1 .
5 Myrmecophaga (Tamandua, Ant-eater)		1 .		

Old World = 5 Species

New World	TYPES	Africa
1 Ai (Three-toed or common Sloth, Ayi)		1 Orycteropus Capensis (Aardvark)
2 Dasypus Peba (Tatouchin or nine-banded Armadillo)		2 Manis longicaudata (Long-tailed Pangolin)
3 Chlamyphorus truncatus (Pichiciago)		Australia
4 Myrmecophaga jubata (Great Ant-eater)		1 Echidna histrix (Porcupine Ant-eater)
5 " didactyla (Little Ant-eater)		2 Ornithorynchus

Scale - 20 of Nature

PACHYDERMATA (THICK-SKINNED ANIMALS)

NEW WORLD

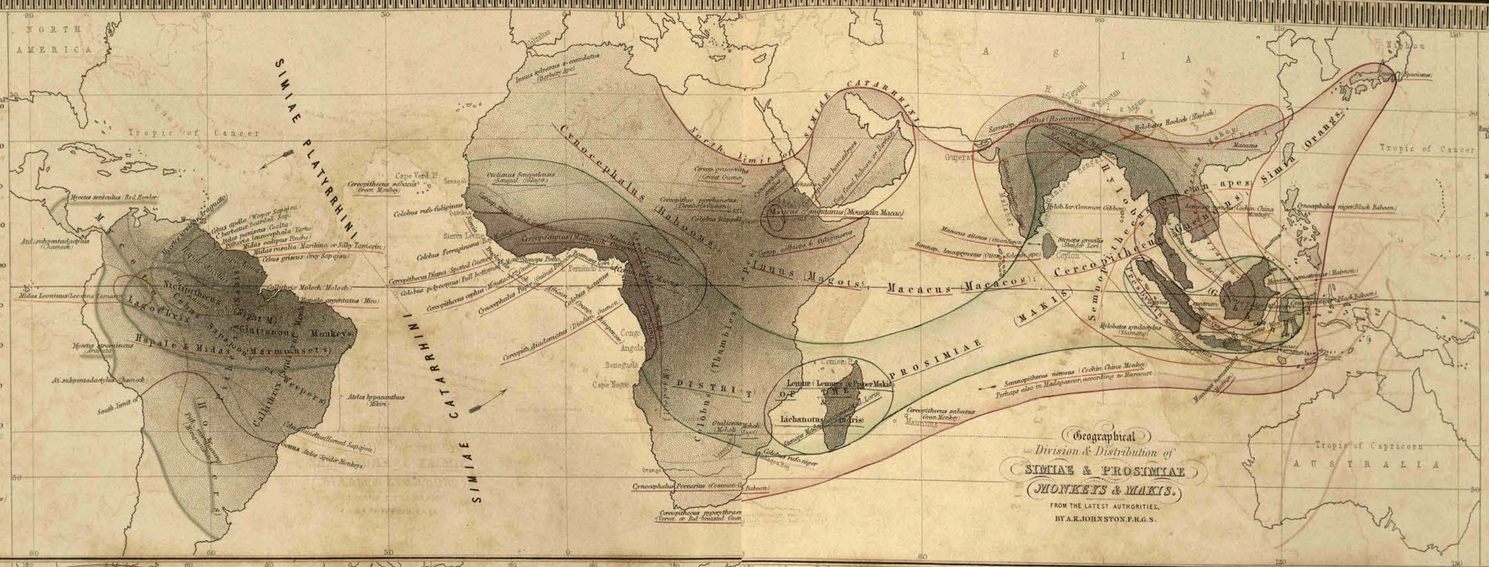
2 Genera
2 Species (1/23 of all Mammalia)

1 Dicotyles (Peccaries)	2 Species		
2 Tapirus (Tapir)	2 .		

OLD WORLD (Continued)

Africa	TYPES	New World
1 Hippopotamus		7 Equus Quagga (Quagga)
2 Rhinoceros Africanus bicornis (two horned R.)		
3 Equus Caballus (Cape Horse or Zebra)		1 Tapirus Americanus (common American Tapir)
4 Sus larvatus (Wanderoo or Booch Varh)		2 " pinchaque (Tapir of the Andes)
5 Phascochoerus Aethiopicus (Ethiopian Wart-hog)		3 Dicotyles torquatus (Collard Peccary)
6 Equus zebra a. montanus (Zebra)		4 " labiatus (White lipped Peccary or Tajassu)

Scale - 20 of Nature



MARSUPIALIA
Comprising 1 Family
OF THE NEW WORLD
Didelphidae (Opossums)
Geographical Division & Distribution of MARSUPIALIA POUCHED ANIMALS Over the Globe
MARSUPIALIA OF THE OLD WORLD
Comprising 7 Fam.s
GEOGRAPHICAL DIVISION & Distribution OF EDENTATA TOOTHLESS ANIMALS
Geographical Division & Distribution of MARSUPIALIA (Pouched Animals.) IN AUSTRALIA &c

MARSUPIALIA (POUCHED ANIMALS)

	14 Gen.	1/22 of all
	125 Spec.	Mammalia

MARSUPIALIA OF THE NEW WORLD = 21 Species
MARSUPIALIA OF THE OLD WORLD = 80 Species

Family	Didelphidae	1 Genus	Didelphys (Opossums)	21 Spec.
	Dasyuridae	3	Dasyurus	7 .
	Myrmecobiidae	1	Thylacynus	1 .
	Peramelidae	1	Perameles	4 .
	Macropodidae	6	Macropus	40 .
		1	Hypsiprymnus	2 .
	Phalangistidae	2	Petaurus (Flying Phalangers)	12 .
	Phascolomyidae	1	Phascolomys (Koala)	1 .
	Dendrolagidae	1	Dendrolagus (Kangaroo)	1 .

TYPES.

1 Didelphys dorsigera (Mariate Opossum)
2 Dasyurus macrourus (Spotted tailed Dasyurus)
3 Perameles Lagotis (Rabbit eared Perameles)
4 Chaeropus ecaudatus (Chaeropus)
5 Macropus Gaecatus (Banded Kangaroo)
6 Phalangista maculata (Spotted Phalanger)
7 Phascolarctos Fuscus s. Ursinus (Koala)
8 Phascolomys Wombat (Wombat)

Scale - 20 of Nature

PACHYDERMATA (THICK-SKINNED ANIMALS)

OLD WORLD = 6 Genera (1/9 of all Mammalia)
35 Species

1 Elephas (Elephants)	2 Spec.	5 Sus Scrofa	9 Spec.
2 Hippopotamus	1 .	6 Phascochoerus Warthogs	3 .
3 Rhinoceros	7 .	7 Equus (Horses)	1 .
4 Hyrax (Daimans)	3 .	8 Equus (Horses) except E. caballus	9 .

OLD WORLD exclusive of AFRICA

TYPES.

1 Elephas Indicus (Indian Elephant)
2 Rhinoceros Indicus (Indian Rhinoceros)
3 Hyrax Syriacus (Syrian Hyrax or Ashoko)
4 Sus scrofa (Wild Boar)
5 Sus Scrofa
6 Phascochoerus Wartthogs
7 Equus Hemionus (Onager)
8 & 9 Equus asinus (Wild Asses)

Scale - 20 of Nature

EXPLANATION

In all the Maps the existence of a class of animals in a particular country or region is indicated by shading, which is darker in proportion as the number of species is greater; and the limits of distribution are shewn by lines, the colours of which correspond with those distinguishing the names of the different animals on each side of the sheet.

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

DISTRIBUTION OF THE SINGLE GENERA.

I.—SIMIAE CATARRHINI (MONKEYS OF THE OLD WORLD).

1. TAILED MONKEYS.

1. *Cynocephalus* (baboons). This genus, which has the greatest number of species, is distinguished by its physiognomy, which resembles that of a dog more than that of any other ape. These are generally large, ferocious, and dangerous apes, and attain to a considerable size, being nearly as large as the wolf. They are arranged by Baron Cuvier in two sub-divisions—(1.) Proper baboons; (2.) Mandrills. One of the most common baboons frequently brought to Europe, is the *Cynocephalus porcarius* (chacma). It is not widely distributed—its chief habitat being the mountainous districts throughout the colony of the Cape of Good Hope. *Cynocephalus hamadryas* (dog-faced baboon or derrias) inhabits the countries near the Red Sea; it is common in Arabia, Abyssinia, and on the borders of the Persian Gulf, but is not found in Egypt or Persia. It extends northward from Abyssinia to the mountains of Arkeeko, on the Red Sea (latitude 15° 20′ north); and, according to Salt and Pearce, it is very common in the Highlands of Tigré. The other species, *Cynocephalus anubis* (Nubian baboon), inhabits Northern and especially Central Africa. It extends farther north than any of the other species, being found in the vicinity of the ancient Meroë. The only species inhabiting Asia is the *Cynocephalus niger* (black baboon), which some naturalists class with the genus *macacus*; it is found on Celebes, and it is doubtful whether or not it occurs on the Philippine Islands. The second sub-division, the Mandrills, inhabit only Central Africa. Of them *Cynocephalus mormon* (variegated baboon, or proper mandrill) extends farthest towards the south, but it does not attain the latitude of the Cape colony.

2. *Inuus* (magots). As already remarked, the Barbary ape, a species of this genus, is the only ape whose habitat comes within the limits of Europe. Its chief habitation is on the precipitous sides of the Rock of Gibraltar, which, as stated by the historian of its celebrated siege, is remarkable for the number of apes that breed in inaccessible places about the summit, and appear in large droves, with their young on their backs, on the western face of the hill.

3. *Macacus* (macaques). These are arranged in two sub-divisions—(1.) The long-tailed macaques or cercopes; (2.) The short-tailed macaques or maimons. To the first, occurring in both continents, belongs the *Macacus cynomolgus* (common macaque), which, by several naturalists, as Salomon Müller, in his splendid work on the Dutch East India Islands, is arranged along with the genus *Cercopithecus*. It is the only ape found on the Island of Timor, which, in this archipelago, forms the eastern limit of apes. Dr Horsfield states that this is the most common species of monkey in the forests of Java; it is very generally domesticated, and kept in the stable along with the horses, in the same manner as goats are in England, under the impression that the smell of them is grateful to these animals. Of the remainder, the *Macacus montanus* (mountain macaque), is peculiar to Africa, its chief habitat being on the elevated mountain chain of Abyssinia, in the provinces of Hadramaut, Sanaen, and Gojjam. The others inhabit chiefly India and Ceylon; and *Macacus sinicus* (tawny macaque) occurs in Pegu, Java, and Sumatra. *Macacus radiatus* (toque, bonnet monkey, bonnet chinois) is a native of the Malabar coast, from Gujerat to Ceylon. No monkey affords greater amusement in the menageries than the bonnet chinois; and the imperturbable gravity with which it accompanies all its actions is truly diverting. The second sub-division, short-tailed monkeys, or maimons, are peculiar to Asia, inhabiting Hindustan, Ceylon, Java, and Sumatra.

4. *Colobus* (thumbless apes). This genus, which contains but few species, and properly forms only a subordinate group of the Asiatic genus, *Semnopithecus* (sobrun apes), is limited to Africa, and occurs principally in the tropical countries of the western coast, where *Colobus caudatus* or *polycomus* (royal thumbless ape or full-bottomed wig) is known to the Negroes of Sierra Leone and Guinea by the name of the king of the monkeys, apparently from the beauty of its coat and its singular load of hair, which resembles a large periwig or a diadem, according to the views of the observers. *Colobus Rüppellii* (mantled thumbless ape) occurs only in the low grounds of the provinces of Gojjam, Kulla, and Damot. It is known in the country by the name of guereza. *Colobus ruffi* or *niger* is said to inhabit the district of Algoa Bay, in South Africa; but it is probable that this name has been mistaken for Delagoa Bay, as the former place has long been the residence of an enterprising British colony, to whom, had it existed then, it must have been known; but they, in specifying the natural productions of the district, make no mention of its occurrence.

5. *Cercopithecus* (guenons) is one of the genera which contains the greatest number of species. The individuals vary considerably in size and colour. They herd in troops, and make great havoc among the gardens and cultivated fields. By far the greater number of cercopithecs with which we are acquainted come from the western coasts of Africa, where, we are assured by different travellers, they swarm in countless multitudes. In the same district of Africa, as well as in Abyssinia, occur the *Cercopithecus nethiops* (collared mangabey guenon), and *Cercopithecus pyrrhonotus* (Ehrenberg's guenon). *Cercopithecus griseo-viridis* (grivet guenon) is also found, according to Cailliaud, in the forests of Nubia. *Cercopithecus erythrogyna*, or *pygerythrœus* (vervet or red-breasted guenon), inhabits the southern part of Africa. It is the only *cercopithecus*, or, indeed, with the exception of the *Cynocephalus porcarius* (chamee), the only monkey found to the south of the River Gariep. The woods throughout the colony of the Cape of Good Hope, especially in the vicinity of the sea, from Cape Town to Algoa Bay, and thence through the whole extent of Caffreland, abound with this species. *Cercopithecus fuliginosus* (white eyelid monkey), according to Pennpper, inhabits the Island of Madagascar. In making this statement, however, he has been misled by Buffon, who says that it is found in that island; but F. Cuvier has clearly ascertained that its proper habitat is in Western Africa. The few Asiatic guenons which, for the greater part, inhabit the Continent of India, are, *Cercopithecus cephalopterus* (black-faced monkey), *Cercopithecus auratus* (golden guenon), *Cercopithecus talapoin* (talapoin monkey), and *Cercopithecus mona* (mona). Only one species, *Cercopithecus fuscus* or *cynosurus* (Malbrook guenon) is common to both continents. It occurs in the forests of Bengal and on the coast of Guinea.

6. *Presbytis* (tailed gibbons). The only species of this genus, namely, the capped-monkey, is an inhabitant of the Island of Sumatra.

7. *Semnopithecus* (solemn apes). These are distinguished by a very long tail and a slender, elongated body. They are remarkable for mildness of disposition, great intelligence, and a slowness in their movements—quite the opposite of the vivacity and petulance of the guenons. In India, where they occur in great numbers, they are treated by the natives with a kind of religious veneration. *Semnopithecus maurus and cucullatus*. These two species form, according to Geoffroy and other naturalists, a distinct genus—that of *nasalis*. So also Illiger distinguishes *Semnopithecus nemœus* (Douc or Cochin-China monkey) as a separate genus, that of *laniopygus*. The former are peculiar to Asia and extend from China to Gujerat, over all India, Ceylon, and the South-eastern Archipelago. Harcourt's discovery of this monkey in Madagascar still wants confirmation. The principal species are *Semnopithecus nemœus* or *larvatus* (proboscis monkey or kahau), which is distinguished from every other mammiferous animal by the form of its nose, which is from four to five inches in length, narrow at the extremity, and having a furrow in the middle, apparently dividing it into two lobes. It is the only ape of the genus *nasuosa* which occurs in China; and it extends thence over Cochin-China, the Malay Peninsula, and Borneo, where its flesh is much prized by the natives. *Semnopithecus entellus* (hoonuman), often misspelled houlman. It is highly venerated by the Hindus. Though an inhabitant of the hot plains of India, it ascends the Himalayan Mountains wherever it can find wood. It occurs in Nepaul, on the elevated plains of Bhootan and in Assam, and even in Amboa and Bengal. The celebrated banyan tree, called cubbeerdur, on the banks of the Nerbudda River, is the residence of a numerous colony of hoonumans. *Semnopithecus nemœus*, (Douc or Cochin-China monkey) is one of the most beautiful of its tribe; its chief habitat is in Cochin-China. The remaining species occur chiefly in the great Sunda Islands.

2. TAILLESS MONKEYS.

1. *Hylobates* (gibbons, or long-armed apes) inhabit only the most secluded parts of India and the Eastern Archipelago. *Hylobates syndactylus* (sindactylus gibbon or siamang). It is also called ungka by the Malays of Singapore. This is the largest of the genus. It is slow in its movements—dull and stupid. In the forests of Sumatra, where they are very common, it is said that these gibbons assemble in large companies, and are conducted by a chief. *Hylobates hoolock, concolor* or *Boffloni* (hoolock) is an inhabitant of the mountains and the territory of Assam; it is also met with on the Garrow Hills, in latitude 25° to 28° north; all the others belong to Malacca and the Island of Sumatra.

2. *Simiae* (orangs). The Asiatic orang-outang is found occasionally in the flat woodlands in the south and west coasts of Borneo, although never to any great extent. It has entirely disappeared from the vicinity of Borneo town, having been driven from the blickly populated part of the island. On Sumatra, it inhabits the low woodlands on the east coast, especially towards the north, and extends thence over Malacca and the southern part of Assam. It is of solitary habits, living generally alone. The habitat of the African *orang-outang*, in so far as ascertained, extends from the banks of the Gambia to the southern boundary of Benguela, comprehending the whole coast of the Gulf of Guinea, and enclosing an extent of 12° of latitude on each side of the equator. It occurs chiefly in the interior of the country, and it appears more frequently on hills of moderate elevation than on plains.

II.—SIMIAE PLATYRRHINI (MONKEYS OF THE NEW WORLD).

In many respects these monkeys differ in a remarkable manner from those of the Old World. The most striking external difference consists in the smaller size and less ferocious manners of the greater number, the prehensile tail of many; and in all the naked callosities and the want of cheek-pouches. Buffon first proposed the division of this family into two sub-tribes—*the sapajous* and *the saguins*, according as their tails are or are not prehensile.

1. SAPAJUS (SAPAJOUS).

Mycetes (howlers). Animals of this species derive their name from the remarkable howling sound they emit, which resembles the grunting of a herd of swine. They are, in general, of a large size, and have the widest circle of distribution of the entire genus, extending farthest to the north as well as to the south. The species which stretches farthest to the north in Central America is, *Mycetes seniculus* (uono colorado, royal or red howler), the figure of which is given among the typical representations. *Mycetes ursinus* (ursine howler, or araguato). This, which differs little from the preceding species, is an inhabitant of the northern part of South America and Brazil. *Mycetes stramineus* (straw-coloured howler, arabata), an inhabitant of Peru, is one of those which rarely occur on the east side of the Andes. *Mycetes niger* (caray or black howler), which extends to the southern districts of Paraguay, is one of the most corpulent of monkeys, the flesh of which is preferred by the Portaguese in Brazil to that of ducks.

2. *Ateles* (spider monkeys). In their general contour they resemble the guenons of the Old World. They are generally mild, timid, melancholy, and slow in their movements. They inhabit chiefly the countries of Brazil and Guayana, and do not extend southward farther than to the parallel of Rio de Janeiro. *A. hypoxanthus* (Mikiri) often erroneously spelled Miriki, are very plentiful in the maritime provinces of Brazil, from St Paul to Bahia, and extend only between the latitudes of 12° to 23° south.

3. *Lagothrix* (gluttonous monkeys). The genus *lagothrix* of Cuvier and Geoffroy is called *gastrimargus* by Spix; and this has sometimes led to the error of considering it as two separate genera. Only two species are known, and these inhabit chiefly the tropical countries of the interior of South America; indeed their constitution renders them so dependent on the heat of tropical climates, that a specimen brought on its way to Europe dies from the effects of cold by the time it reaches the Azores.

4. *Cebus* (weepers). The animals comprising this genus are of a mild disposition; they are quick and lively in their movements, and are very readily tamed; they are excellent climbers, and in all their members show a great adaptation for a sylvan life. The name "weeper" is derived from the plaintive cry which they utter. This genus has the greatest number of species of any ape in the New World; but its circle of distribution is more limited than many of the others. It extends southward to about the Tropic of Capricorn. On the west it scarcely reaches to the foot of the Andes, and is not found in the northern part of Venezuela. It is found in the greatest numbers in Guayana, and is frequently brought to Europe.

2. SAGUINS (SAGOUINS).

1. *Pithecia* (sukis or fox-tails). Several of the saguins, from their having long and bushy tails, have been called fox-tailed monkeys. This genus is one of them. One species having the tail smaller than the body, is by Spix separated from the remainder, to form his genus *Brachyurus*. The *pithecias* usually reside in the depths of the forest, where they conceal themselves, or sleep during the day. They extend over the countries from the banks of the Orinoco to Paraguay and the province of Chaco. *Pithecia satanas* (black fox-tail). The limits of distribution of this species is distinguished on the map, and a representation of it is given among the types.

2. *Callithrix* (squirrel monkeys). This genus is of a small size, and prettily coloured. Its chief habitat is on the banks of the Orinoco.

3. *Nyctipithecus* (night monkeys). These differ from the other saguins only by their large nocturnal eyes, and by having their ears partly concealed under the hair. They have a strong general resemblance to the lors of the Old World. They inhabit the countries of Guayana and Brazil.

4. *Hapale* (ouistitis) } 5. *Midas* (tamarins) } marmousets. These are diminutive animals, of an agreeable form, having a tail longer than the body; their fur is generally long, bushy, and very soft to the touch, and of brilliant and beautiful colours. Their chief habitat is Brazil; but they extend also to Guayana and the northern districts of South America to the banks of the Rio Magdalena. Of the genus midas the most remarkable is *Midas Lamina* (leonine tamarin or leonite). It is a very rare species, and inhabits the plains of Mocoa, bordering the eastern slope of the Cordilleras and the fertile banks of the rivers Putumayo and Cuequeta, and never ascends to the more temperate districts. It is only from seven to eight inches in length, and is extremely elegant. It is playful in its disposition, but is easily angered. Humboldt, who discovered this species, observes, that when enraged or tormented, it bristles up the hair of the neck, so as to increase its resemblance to a miniature lion; its cry resembles the chirrup of some small bird.

III.—PROSIMIAE (MAKIS).

The makis, according to Linnæus, comprise all those quadrumanous animals whose incisors are more or less than four in number, or whose teeth are directed differently from those of the apes or monkeys. They vary very much in size, and are generally very small; most of the species are not larger than a rat or mouse, with the exception of those of the genus *lichanotus* (indris), which attain to the size of the baboon. The two first genera *lemures* (lemurs) and *lichanotus* (indris) inhabit only Madagascar, with the adjacent islands, and Mozambique. In the same district there occurs, of the remaining genus, *nycticebus* (galagos), and on the continent of Africa, *otenops* (lorises). In Asia, there occur only the small, harmless animals, the *lorises* and *tarsiers*, which, on account of their mysterious conduct—their nocturnal prowling and their extraordinary large, sparkling eyes—have existed in the imaginations of the natives the most superstitious feelings. They ascribe to them the most singular peculiarities, in consequence of which they are regarded by young and old with the greatest mistrust. *Tarsius spectrum* (podgy tarsier) is found only in the islands of Celebes, Borneo, Salayer, and Banca; but the lorises occur also in the Islands of Sumatra and Ceylon, as well as on the Continent, in Siam and Bengal.

PERPENDICULAR DISTRIBUTION.

In the Zoological division of our Atlas, we have attempted to show, by diagrams, the perpendicular distribution of animals with reference to the snow line, the limits of trees, and other important meteorological and botanical circumstances, which have so great an influence on the animal world. The scale of these diagrams is made to correspond with those on the Map of Botanical Geography (No. 1), in order to show at once the striking connection that subsists between the two kingdoms; but, on the present map, want of space has limited these diagrams to the first of the four orders of animals represented, namely, that of the monkeys, for which, however, the greatest number of observations exist. On the second map of this division, containing the *Carnivora*, will be found, interesting representations of the different animals which inhabit mountainous regions.

Among the monkeys of the Old World, the *Semnopithecus entellus* (hoonumans) ascend to the greatest height. They are found in Nepaul and Bhootan in great numbers, and ascend the Himalayan Mountains wherever they can find wood—that is, to a height of above thirteen thousand feet. In Africa, *Macacus montanus* (mountain macaque) ascends the Abyssinian Highlands, to a height of eight thousand feet. In the New World, *Mycetes ruginosus* (beelzebul) ascends the eastern declivity of the Andes to a height of above eleven thousand feet.

SECOND SECTION.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF THE MARSUPIALIA (*POUCHED ANIMALS*) IN THE WHOLE WORLD GENERALLY, AND IN AUSTRALIA, &c., SPECIALLY.

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

In the construction of this section of our map we have been principally indebted to the ample and admirably arranged materials furnished by Mr Waterhouse, in his recent publication on Marsupial quadrupeds[1] and we have followed the classification therein adopted, which is based on that of Professor Owen, communicated to the Zoological Society in 1839, with the exception of the two last named genera: *echidna* and *ornithorynchus*, forming the family of *Monotremata*, for which we have substituted the genus *dendrolagus*, recently discovered by Salomon Müller, in New Guinea. In form, the dendrolagus resembles the kangaroo, but in its power of climbing it is more nearly allied to the phalanger.

Of all the orders of Mammalia, there is none the knowledge of which is more rapidly and steadily extending, than that of the Marsupialia. Australia is the great central locality of these animals; and the more this singular country is explored, the more ample does our list of its genera and species become. Mr Waterhouse reckons, in all, 105 species—nearly twice the number named in many recent treatises; and since the time of his publication (1841) 18 new species have been discovered, and described in the proceedings of the Zoological Society of London. The greater part of these are kangaroos, ten of which have been discovered in Western Australia, others at Port Essington on the north, and on Barrow Island on the north-west coast. We may, therefore, assume the number of species known at the present time (November 1845), at 123 species, forming one-twelfth of all Mammalia.

The classification referred to is as follows :—

	Families.		Genera.	No. of Species.
Marsupialia of the New World, = 21 Species.	*Didelphidæ*	1.	Didelphys (Opossums)	21
Marsupialia of the Old World, = 87 Species.	*Dasyuridæ*	2.	Thylacinus	1
		3.	Dasyurus	5
		4.	Phascogale	7
	Myrmecobiidæ	5.	Myrmecobius	2
	Peramelidæ	6.	Perameles	7
	Macropodidæ	7.	Charopus	1
		8.	Macropus (Kangaroos)	40
		9.	Hypsiprymnus	10
	Phalangistidæ	10.	Phalangista (Phalanger)	15
		11.	Petaurus	10
		12.	Phascolarctus (Koala)	1
	Phascolomidæ	13.	Phascolomys (Wombat)	1
	Dendrolagidæ	14.	Dendrolagus	2

The Marsupialia are distributed over the countries within the torrid and temperate zones of Australia, the Asiatic Archipelago and America; but in Africa, and on the Continent of Asia, no pouched animal is known to exist. In America they extend farthest towards the north, reaching to the southern borders

[1] Naturalist's Library, vol. xi.—Marsupialia, or pouched animals. By G. R. Waterhouse, Esq., Curator of the Zoological Society of London.

scale for the giant apes of the *Pachydermata*, is equal to one-sixtieth of nature, consequently three times smaller than the former; hence the figures must be magnified sixty times, in order to equal the natural size. At the head of each group of typical animals is given a complete statistical enumeration of the genera with the number of their species, and at the foot, a table of reference to their names.

The line of colour which accompanies the name of each genus corresponds with the limiting line of its distribution on the map.

FIRST SECTION.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF THE *QUADRUMANA* (*FOUR-HANDED MAMMALIA*) COMPRISING: *SIMIAE* (*MONKEYS*) AND *PROSIMIAE* (*MAKIS*).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The monkeys are divided into two families: 1. *Simiæ catarrhini*; 2. *Simiæ platyrrhini*. Simiæ catarrhini, monkeys with oblique and very wide-set nostrils, and a human-like system of teeth, are found only in the Old World; and Simiæ platyrrhini, monkeys with nostrils placed at the side, and wide-asunder, and with three false grinders on each side of both jaws, occur only in the New World. The monkeys contain in all 170 species, forming one-ninth of all Mammalia.

Simiæ catarrhini (*the monkeys of the Old World*), comprising in all 79 species, or one-nineteenth of all Mammalia, are arranged in the following two groups and eleven genera:—

I. *Tailed monkeys*, = 72 *species*.	
1. Cynocephalus (Baboons),	25 species.
2. Inuus (Magots),	3 "
3. Macacus (Macaques),	9 "
4. Colobus (Thumbless apes),	7 "
5. Cercopithecus (Guenons),	17 "
6. Presbytis (Tailed Gibbons),	1 species.
7. Semnopithecus (Sclenna apes),	12 "
II. *Tailless monkeys*, = 7 *species*.	
1. Hylobates (Gibbons or long-armed apes),	5 "
2. Simia (Orangs),	2 "

Simiæ platyrrhini (*the monkeys of the New World*), comprising in all 91 species, or one-sixteenth of all Mammalia, consist likewise of two groups and nine genera:—

I. *Sapajus* (*Sapajous*), = 43 *species*.		II. *Sajuinæ* (*Sajouins*), = 48 *species*.	
1. Myeetes (Howlers, or howling apes),	9 species.	1. Pithecia (Sakis or Fox-tails),	12 species.
2. Ateles (Spider monkeys),	9 "	2. Callithrix (Squirrel monkeys),	11 "
3. Lagothrix (Gluttonous monkeys),	2 "	3. Nyctipithecus (Night monkeys),	3 "
4. Cebus (Sapajous or Weepers),	23 "	4. Hapale (Ouistitis) or Marmosets),	10 "
		5. Midas (Tamarins)	12 "

The *second family*, or that of Prosimiæ (Makis), consist of 32 species, or one-forty-seventh of all Mammalia, which are divided among the individual genera in the following manner:—

1. Lemur (Lemurs),	14 species.	4. Otolicnus (Galagoes)	4 species.
2. Lichanotus (Indris),	2 "	5. Tarsius (Tarsiers),	6 "
3. Stenops (Lorises),	6 "		

The Quadrumana differ from man, to whom, of all animals, they bear the nearest corporeal resemblance, especially in this, that they inhabit only a particular portion of the globe, whilst the human race is (with the exception of some polar deserts) spread over the whole earth, and in this respect can hardly be said to have any limits. The torrid regions, both of the Old and New World, constitute the dwelling-place of monkeys. The whole of Africa, except Egypt, is occupied by them, from the Cape of Good Hope to the Strait of Gibraltar; here the Turkish or Barbary ape, *Inuus sylvanus s. ecaudatus*, a magot, is remarkable as the only one of its family which, quitting its native country, is found within the geographical limits of Europe, being still abundant on the Rock of Gibraltar, latitude 37° north. In an equally high latitude, on the eastern border of the Old World, another magot, *Inuus speciosus*, is found in the Island of Niphon. But the true native country of the Asiatic ape is India, the continent, including the southern part of China, as well as, and indeed more especially, the Archipelago, to the meridian of the east end of Timor. This island, as well as Celebes, forms, with the Philippines, the eastern limit of the distribution of apes in the torrid zone of the Old World. Beyond this no apes are found; for in the west Australian islands, the continent of Australia and the islands of Polynesia, four-handed quadrupeds are unknown.

But in America they again appear, and occupy almost the entire half of this part of the earth, from Honduras, latitude 16° north, to beyond the pampas of Buenos Ayres, latitude 38° south. Here, in the New World, consequently, the distribution of apes is confined to a space of 54°, whilst in the Old World, between Gibraltar and the Cape of Good Hope, it extends to 72° of latitude, and on both sides of the Atlantic. Their favourite resort is in the table-lands covered with primitive forests.

DIVISION AND INTENSITY OF THE SINGLE SPECIES.

In the following table we have represented the division of each single genus of the monkeys and makis, in the different regions of the Old and New World, according to the number of their species. On the map the same information is conveyed graphically, by means of shading, so that where the shading is darkest the number of species is greatest. In this table we have selected those countries in which the species present the greatest characteristic distinctions; and, therefore, the political divisions are not so much attended to as the physical boundaries of countries; thus, for example, in the valleys of Hindustan more monkeys occur than in the table-land of the Deccan, and accordingly these districts are separated in the table. It must be observed, however, that the greater or less apparent density in the several regions must depend, in part, on the more or less accurate observations that have been made in them. The banks of the Orinoco and Magdalena, in South America, for example, having been thoroughly explored, may appear to have a greater number of species than other districts which, not having had this advantage, are, on account of this uncertainty, not so deeply shaded. Yet, we may observe at a glance, that the apes are concentrated in the countries under the equator, and that there they attain their maximum. Of the three equatorial regions of Asia, Africa, and America, that of America (Brazil) has by far the greatest number of species, the amount being nearly double that of the continents of the Old World. Probably the greatest number of species of apes occur in the selvas—the immense wooded plains on the banks of the Amazon River; from this they extend to the eastern declivity of the Andes, but very seldom pass over them, since, on the whole western side of the Cordilleras, from Panama to Chile, one species only, the *Ateles pentadactylus* (five-fingered spider monkey) occurs in Peru, where the *Ateles melanochir* (black-headed spider monkey) is also said to be found. As the maximum of all the apes of the New World are found in Brazil, so also the maximum of each single genus occurs there; there being only one genus in Guayana—that of the cebus (weepers), —which has one species more.

Of the nine genera of *monkeys in the Old World*, five belong to both continents of Asia and Africa, namely, the baboons, magots, macaques, and guenons, of the group of the *tailed monkeys*, and the orangs, of the group of the *tailless monkeys*.

The baboons occur in greatest numbers in tropical Africa. Of the genus of the magots, none of the districts contain more than one species. The macaques are most numerous in Hindustan, and the guenons on the western coast of Africa, where all the species except two are found. Of the two species of the orangs, one occurs in the tropical Archipelago of Asia, and the other in tropical Africa. Besides these five genera common to both continents, there are three which occur only in Asia and one in Africa, these are the tailed and the proper gibbons, which are most numerous in the Island of Sumatra and the peninsula of Malacca; and the solemn apes, which occur in greatest numbers on the islands of Borneo, Sumatra, and Java. The thumbless apes in Africa, representing the solemn apes of Asia, are most numerous in tropical Africa.

The Island of Madagascar is the chief habitat of the makis:—

TABLE SHOWING THE DIVISION OF *SIMIAE* AND *PROSIMIAE* (*MONKEYS* AND *MAKIS*), OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

I. SIMIAE CATARRHINI (MONKEYS OF THE OLD WORLD.)

Regions and Countries. (From North to South.)	a, Tailed monkeys.								b, Tailless monkeys.			Amount of all forms Catarrhini.
	1. Cynocephalus (Baboons.)	2. Inuus (Magots.)	3. Macacus (Macaques.)	4. Colobus (Thumbless apes.)	5. Cercopithecus (Guenons.)	6. Presbytis (Tailed gibbons.)	7. Semnopithecus (Semnos apes.)	Amount of the Tailed monkeys.	1. Hylobates (Gibbons.)	2. Simia (Orangs.)	Amount of the Tailless monkeys.	
	N	*n*	*m*	*b*	*c*	*p*	*sp*	*the*	*Spe*	*cies.*		
Asia.												
Island of Nipbon,	.	.	.	.	.	.	1	1	.	.	.	1
Persia and Arabia,	1	.	.	.	.	.	.	1	.	.	.	1
India, including Nepaul, Bhootan, and Assam, from the southern declivity of the Himalaya to the parallel of the Nerbudda River and Calcutta (about 22° north latitude),	.	.	4	.	.	.	2	6	3	.	3	9
China and Eastern India, with the exception of Malacca and the Philippine Islands,	1	.	2	.	.	.	1	4	1	1	2	6
India, from the parallel of Nerbudda River and Calcutta,	.	.	2	.	3	.	1	6	2	.	2	8
Ceylon,	.	.	2	.	.	.	1	3	.	.	.	3
Malacca,	.	.	1	.	.	.	2	3	3	1	4	7
Sumatra,	.	1	3	.	2	1	6	13	4	1	5	18
Borneo,	.	.	.	.	.	.	7	7	1	1	2	9
Java,	.	.	3	.	.	.	6	9	1	.	1	10
Molucca Islands, with Celebes and Timor	1	.	1	.	1	.	.	3	2	.	2	5
Africa.												
Northern Africa (except Egypt) to the parallel of Timbuctoo, or 18° north latitude,	.	1	.	.	.	.	.	1	.	.	.	1
Nubia and Darfur,	2	.	1	1	3	.	.	7	.	.	.	7
Abyssinia,	1	.	1	1	1	.	.	4	.	.	.	4
Western and Central Africa, from the parallel of the River Senegal to Cape Negro, about 16° on each side of the equator; with the adjacent islands,	3	.	1	6	15	.	.	25	.	1	1	26
Southern Africa, especially south of the Orange River,	1	.	.	.	1	.	.	2	.	.	.	2
Island of Mauritius	.	.	.	.	1	.	.	1	.	.	.	1

II. SIMIAE PLATYRRHINI (MONKEYS OF THE NEW WORLD).

	a, Sapajus (Sapajous.)					b, Sajuins (Sajouins.)						Amount of all Simiæ Platyrrhini.
	1. Myetes (Howlers.)	2. Ateles (Spider monkeys.)	3. Lagothrix (Gluttonous monkeys.)	4. Cebus (Weepers.)	Amount of the Sapajous.	1. Pithecia (Sakis or fox-tails.)	2. Callithrix (Squirrel monkeys.)	3. Nyctipithecus (Night monkeys.)	4. Hapale (Ouistitis.)	5. Midas (Tamarins.)	Amount of the Sajouins.	
Central and South America.												
Honduras, Panama, the western part of New Granada, to the eastern declivity of the Andes, and the mountainous northern part of Venezuela,	3	2	.	1	6	.	.	.	1	1	2	8
Guayana (English, Dutch, and French),	1	3	.	7	11	4	1	.	2	3	10	21
District of the River System of the Orinoco and Cassiquiare,	1	1	1	1	4	3	3	1	1	.	8	12
Ecuador, Peru, and Bolivia,	1	2	1	1	5	1	1	.	1	1	4	9
Brazil,	5	5	1	6	17	6	8	2	7	6	29	46
Paraguay, and the province of Chaco, with the other countries to the south polar limit of the monkeys	1	.	.	.	1	1	.	1	.	.	2	3

III. PROSIMIAE (MAKIS.)

	1. Lemur (Lemurs.)	2. Lichanotus (Indris.)	3. Stenops (Lorises.)	4. Otolicnus (Galagoes.)	5. Tarsius (Tarsiers.)	Amount of all Prosimiæ.
Africa.						
Western and Central Africa,	.	.	1	2	.	3
Island of Madagascar, adjacent islands, and Mozambique,	14	2	.	1	.	17
Asia.						
Bengal and Coromandel,	.	.	2	.	.	2
Ceylon,	.	.	1	.	.	1
Siam,	.	.	1	.	.	1
Indian Archipelago (Sumatra, Borneo, Java, Celebes, Salayer, and Banca)	.	.	1	.	1	2

OLD WORLD.

5. *Oryctéropus* (African ant-eaters). This genus has only one species—*Oryctéropus capensis* (Aard-vark), which inhabits the countries of the Cape Colony, and extends northwards to Congo. It is essentially burrowing in its habits. The burrows formed by these animals are dangerous to waggons travelling over the country; as in districts where they are numerous, and where also vast numbers of ant-hills cover the plain, horses and cattle, breaking through the surface of the ground, suddenly stumble and fall.

6. *Manis* (pangolins, or scaly ant-eaters). These are common to Asia and Africa; the species represented in the types—*Manis longicaudata* (long-tailed pangolin)—is the best known species, and inhabits Senegal and Guinea. Of the two species of the Edentata found in Asia, both belonging to the genus manis, the one, *Manis brachyura* (short-tailed pangolin), occurs in Bengal, Bahar, Nepaul, the southern districts of China, and the Island of Formosa. It is very common in the Deccan in India.

7. *Echidna s. tachyglossus* (porcupine ant-eater, the hedgehog of the colonists of Sydney). This species is also characterized by the total absence of teeth. It is a native of Australia, and is most common in New South Wales. It occurs also in the islands in Bass' Strait, and in Van Diemen's Land.

8. *Ornithorynchus* (water mole of the colonists—mallangong and lambreet of the natives). This is the most singular animal belonging to the class Mammalia, and is of peculiar interest, especially to the physiologist. From its duck-like beak and webbed feet, it appears externally to partake in some degree of the nature of a bird, and its first discovery created the most lively astonishment among naturalists. Hitherto it has only been found in the south-eastern parts of Australia, namely in the rivers Yas, Murrumbidgee, Fish, Newcastle, Campbell, and Macquarie.

FOURTH SECTION.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF THE PACHYDERMATA (*THICK-SKINNED ANIMALS*).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The order of the Pachydermata, or thick-skinned animals, so called from their tough, puckered, and almost impenetrable hides, contain, in all, nine genera, and thirty-nine species, exclusive of the feral or wild horse, and all domesticated Pachyderms, as the horse, the ass, the mule, and the swine, which are here entirely left out of view. These thirty-nine species form one-thirty-eighth of all Mammalia, and are divided among the genera in the following order:—

1.	Elephas (Elephants),	2 species.
2.	Hippopotamus,	1 "
3.	Rhinoceros,	7 "
4.	Hyrax (Dumans),	3 "
5.	Sus (Swine),	9 "
6.	Phacochoerus (Wart Hogs),	3 "
7.	Dicotyles (Peccaries),	2 "
8.	Tapirus (Tapirs),	3 "
9.	Equus (Horses),	9 "

The Pachyderms, as well as the three other orders of animals represented on this map, are found chiefly in the countries of the torrid zone; but they extend farther towards the poles than the others, especially in the Northern Hemisphere of the Old World, where they attain to latitude 57° 30° north. In the Southern Hemisphere they do not attain the same latitude, since the common American tapir forms the southernmost member of the order, in about latitude 40° south. In North America no thick-skinned animal is found, unless the wild horse (of which large herds are found in Western Mexico, California, and the river districts of the Columbia) be considered as indigenous to the New World. The Continent of Australia contains no animal whatever belonging to this order. Of the four orders represented on this map, the Pachyderms alone are found in Europe and Central Asia, to the north of the Himalayan Mountains.

These animals generally frequent retired forests and thick jungles, preferring such as are watered by some noble stream, in which they can bathe and wallow during the hotter parts of the day.

DIVISION AND INTENSITY OF THE SPECIES.

A comparison of the typical animals of this order, represented on the borders of the map, will show at a glance how few in number and how small in size those of the New World are, in comparison with those of the Old World. The abundance of Pachyderms in the Old World seems to compensate for the paucity of the pouched and toothless animals; thus tending to restore the balance of the fauna of the different continents of the globe. The greatest number of species of Pachyderms, as shown, by the shading on the map, occur in Africa, to which country the hyppopotamus, zebra, wart hog, and the greater number of the hyrax, are peculiar.

TABLE SHOWING THE DIVISION OF THE *PACHYDERMATA* (*THICK-SKINNED ANIMALS*) OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

REGIONS.	Elephas (Elephants.)	Hippopotamus.	Rhinoceros.	Hyrax (Dumans.)	Sus (Swine.)	Phacochoerus (Wart-hogs.)	Dicotyles (Peccaries.)	Tapirus (Tapirs.)	Equus (Horses.)	AMOUNT OF ALL SPECIES.
	M U M	M U M	M U M	M U M	M U M	M U M	M U M	M U M	M U M	
OLD WORLD.										
EUROPE.										
Central and Southern Europe, from about 37° north latitude	.	.	.	.	1	.	.	.	.	1
ASIA.										
Central Asia, from about 54° to 70° north latitude, or from the Lake of Baikal and the Siberian plains at Omsk, to the southern confines of Thibet, including the whole of Arabia and Iran	.	.	.	.	1	.	.	.	5	6
Southern Asia, from 30° north latitude, excluding the Malay peninsula, and including Ceylon	1	.	1	.	1	.	.	.	1	4
Asiatic Archipelago and the Malay peninsula, with the Island of Papua	1	.	2	.	6	.	.	.	.	9
AFRICA.										
Northern Africa, from the southern limits of the Sahara, and the northern declivity of the Abyssinian table-land to 15° north latitude	.	1	.	1	1	.	.	.	.	3
Central and Southern Africa, from the southern limits of the Sahara, with the Island of Madagascar	1	1	4	2	1	3	.	1	3	17
NEW WORLD.										
Central America, from the southern confines of Mexico and South America to the equator	.	.	.	.	.	.	2	2	.	4
South America, from the equator to the pampas of La Plata	.	.	.	.	.	.	2	1	.	3

DISTRIBUTION OF THE SINGLE GENERA.

1. *Elephas* (elephants). These gigantic animals inhabit the tropical forests of Asia and Africa, living in herds, in a state of inoffensive quiet, unless when attacked by some of the larger and stronger animal assailants, or by their powerful and more relentless enemy—man. *Elephas Indicus* (Indian or Asiatic elephant). As its name implies, this animal is a native of the Indian world. Its habitat extends from the southern point of Sumatra, latitude 6° south, through that island, across the peninsula of Malacca, over the southern provinces of China, Yun nan, and Kwang-se, and in all India on both sides of the Ganges, including Ceylon, to the marshy woodlands of Tarai, which are situated between the River Ganges at Hurdwar, and Ram Ganges, along the foot of the Himalaya, to nearly 30° north latitude. It ascends the Himalayan Mountains, in the forest wilderness of Nepaul, to a height of from five to six thousand feet.—In reference to the occurrence of the Indian elephant in the Asiatic Archipelago, Salomon Müller, who has so thoroughly studied the fauna of these islands, says that Sumatra alone has been known from the earliest times as the habitation of this animal; and that after the most minute research, he could find no trace of it in Borneo. Pigafetta, indeed, states, in his account of the voyage of Magalhaens, that on arriving in the town of Borneo, he found two elephants belonging to the king; but these were probably imported from the continent or from Sumatra, whence young elephants are frequently conveyed to Java, and whence also the royal stables of Pekin have, from time immemorial, been supplied. It is still possible, however, that elephants may be found in the unexplored countries of the northern part of Borneo. Buffon's statement, that the elephant is an inhabitant of Java, is clearly founded on erroneous information.—The native country of *Elephas Africanus* (the African elephant) extends from the northern borders of the Cape Colony to the River Senegal on the west, and to Abyssinia on the east, but in Central Africa it does not appear to extend so far to the north; at least it has not been found in the vicinity of Lake Tchad. In Abyssinia it extends to about latitude 12° north, in the mountains north of Abou Hnaze (south of Sennar); and its highest southern latitude is about 31° south, on the southern borders of the table-land, whence, however, it is receding before increasing cultivation.

2. *Hippopotamus*. This genus, containing only one species, *Hippopotamus amphibius* (common hippopotamus), is peculiar to Africa, where, in former times, it was more widely distributed than at present, since it is ascertained that, at the beginning of the seventeenth century, it was captured even in the Nile Delta, where it was first known by the name of the "river horse." Its present habitation extends from the River Gariep and its tributaries to the Upper Nile in Dongola, where it is very common, and where neither the elephant nor rhinoceros are met with. Burckhardt says, that the hippopotamus is occasionally, though rarely, seen as far north as the Cataracts of the Nile at Es Souan, but in the district of Abyssinia, watered by the Tacazze, a tributary of the Nile, it is very abundant, as well as in the River Niger. It occurs in the River Senegal, and was observed by Clapperton in the Lake Maggubey, Bornou, and in Lake Tchad and its tributary streams. According to Mr Bidwell (Proceed. Zool. Soc. London, 1839), it is not found in the Sierra Leone River, but is very abundant in the Scarcies, about fifty miles farther south.

3. *Rhinoceros*. This genus, which, like the elephant, is common to Asia and Africa, contains three Asiatic and four African species. It is confined to nearly the same limits as the elephant. In Africa, indeed, the limits of the two entirely coincide; and in Asia, the only difference is, that the habitat of the rhinoceros extends a little farther to the north in China, and includes the Island of Java. *Rhinoceros Indicus s. unicornis* (Indian rhinoceros) is a native of the whole Indian continent. It is most abundant in Bengal, and extends to the Chinese province of Sze-chuan. Of the two other species, one, *Rhinoceros Sumatranus*, inhabits Sumatra; and the other, *Rhinoceros Javanus* (Javanese one-horned rhinoceros or warak), the Island of Java. Salomon Müller has not been able to ascertain whether or not the rhinoceros occurs in Borneo; he could only learn that one of the natives had, in his youth, seen a specimen about the size of a buffalo; but he made many interesting observations on their distribution in the Islands of Java and Sumatra. In consequence of their great strength, and their indifference to the changes of climate, these animals wander from the sea-shore to the summit of the bell-shaped volcanoes of Java, where their foot-prints, furrowed to a depth of several feet, are often observed to a height of nearly eight thousand feet, in the rough and naked vicinity of the craters.—Of the African rhinoceros, which consists of three species with two horns, and one species with one horn, the common, or two-horned African rhinoceros, has the largest district of distribution, occupying the same extent of country as the African elephant, whilst the three other species are more confined to the interior. *Rhinoceros simus* (white or blunt-nosed rhinoceros) occurs in great abundance near Litakou, latitude 26° south. *Rhinoceros keitloa* (Keitloa), the African one-horned rhinoceros, is found, according to Burckhardt, in the territory above Sennar; and Bruce says that it occurs near Cape Guardafui; and it may be added, on the authority of Mr Freeman, that it is not uncommon in Makoon, north of the Mozambique Channel

4. *Hyrax* (dumans). Receding, in its pigmy size, from the great bulk of the proboscidean animals, this, the smallest of the thick-skinned Mammalia, approaches nearest in form to the Glires or Rodentia, looking like a diminutive hare. Its district is not extensive, having hitherto only been observed in Southern Africa, in the Nile countries, and in Syria. The most common species in Southern Africa is *Hyrax capensis* (Cape hyrax, or dassie of the colonists). It is abundant on the sides of Table Mountain, where it inhabits the crevices of rocks. Another species (*Hyrax arboreus*) was observed by Mr Smith in the interior of the country. *Hyrax Syriacus* (Syrian hyrax—ashkoko of the natives of Arabia—Israel's sheep of the Arabs) extends from the Abyssinian province of Amhara to the mountains of Horeb and Sinai, and is very abundant on Mount Libanus.

5. *Sus* (swine). These have the largest district of distribution of all the Pachyderms, and assume, in different countries, the greatest variety of forms; for the *phacochoerus* in Africa and the *peccaries* in America are only varieties of the swine. The true swine are distributed in three groups, namely, the European-Asiatic, the Indian, and the South African groups. The European-Asiatic group consists of the *Sus scrofa* (the wild boar), which extends from the Atlantic coasts of France and Morocco to the shores of Japan and the Chinese Sea, on the one side, from the Gulf of Tonquin to Lake Baikal in Siberia; and on the other, from the borders of the Sahara to the Lithuanian woodlands (which, in the heart of European cultivation, still resemble primitive forests). Thence the wild boar sometimes strays to the Baltic provinces of Russia, where, in Courland, it is occasionally followed by the daring huntsman; but it is unknown in the European countries bordering on the western parts of the Mediterranean; therefore, the statement which is occasionally met with in geographical books, that "it is followed in a wild state by impassioned hunters" in Spain and Portugal, is erroneous. Even in France the wild boar is now very rarely met with. The Indian group contains in all six species, of which three have been recently discovered by Salomon Müller; but none of these can be compared in size and ferocity to the European wild boar. The Indian swine are distributed not only over the Asiatic Archipelago and the peninsula of Malacca, but also over the Island of Papua. *Sus babirussa* (babirousa), the most strange of all the species, inhabits the Island of Celebes, Bouro, and some of the Xulla Islands; but it is not found either in Amboina, Ceram, Timor, or any of the greater western islands of the Asiatic Archipelago. The three species recently discovered by Salomon Müller are *Sus verrucosus*, *timoanensis*, and *barbatus* (white boar of Borneo). *Sus papuensis* (Papuan hog), which forms a passage to the American genus, *dicotyles*, is very common in the forests of New Guinea. In the south African group *Sus larvatus* (masked boar, wood swine, or Bosch vark) extends from the woods of Sinikanna, through the south-eastern part of Africa, and is the only pachydermatous animal found in the Island of Madagascar.

6. *Phacochoerus* (wart hogs). These animals belong exclusively to Africa, and extend from Senegambia and Abyssinia to the coasts of the Cape Colony; but within these limits they are very rare, occurring chiefly in remote regions. *Phacochoerus æthiopicus* (South African phacochoerus, vlake vark or African boar, is found along the River Senegal, in Guinea, and through the whole of Central Africa, from the table-land of Abyssinia to the Cape Colony. Two others are found in Abyssinia, and *Phacochoerus Aëliani s. Africanus* (Abyssinian wart hog) occurs also in Kordofan.

7. *Dicotyles* (peccaries). These are the only indigenous representatives of the porcine group in the New World. *Dicotyles torquatus* (collared peccary—tayetou of the Guaranis), is an inhabitant of the dense forests throughout the greater part of South America, from the peninsula of Yucatan, in Central America, to Paraguay. This species climbs the eastern slopes of the Andes to a height of six thousand feet. *Dicotyles labiatus* (white-lipped peccary, or tajuan), is a native of the countries of Guayana and Paraguay. These animals assemble in vast troops, sometimes in thousands at a time, and are said to be led generally by an old male.

8. *Tapirus* (tapirs). In as far as yet ascertained, this genus contains only three species, of which two are natives of South America, and the other of the Asiatic Archipelago. This is the only thick-skinned animal which is common to both the Old and the New World. *Tapirus Malayanus s. Indicus* (the Malay tapir) inhabits the forests of Malacca, Sumatra, and the northern part of Borneo, which it seldom leaves. On the west coast of Sumatra this animal is found at a height of nearly four thousand feet. According to Abel Remusat, a species of tapir is found in the south-western provinces of China; whether this be the Malay tapir, or a new species, *Tapirus Chinensis*, is not yet ascertained. Of the

of Canada, or to about latitude 42° north. In Van Diemen's Land they attain their southernmost limits, namely, about latitude 43° 30′ south. In the Asiatic Archipelago they are spread over the islands of Celebes and Java; in which last, however, only one species has hitherto been observed, namely, *Macropus Brunii* (filander kangaroo), discovered by Le Brun, in the vicinity of Batavia.

The squirrel-like petaurus (*Pet. sciureus*) extends, according to Cuvier (1827), eastward to Norfolk Island; but as it is not mentioned by any more recent authority, we have marked it doubtful on the map.

DIVISION AND INTENSITY OF THE SPECIES.

The countries embracing the colony of New South Wales, and the south-eastern districts of Australia, contain the greatest number of pouched animals, since there, ten out of the thirteen genera belonging to the Old World are found, and these comprise, in all, thirty-nine species. In the countries just mentioned, and in the Island of Van Diemen's Land, only the largest class of the marsupial animals occur. In order more clearly to exhibit the species belonging to each genus, we have compiled the following:—

TABLE SHOWING THE DIVISION OF *MARSUPIALIA (POUCHED ANIMALS)* OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

REGIONS AND COUNTRIES. (From North to South.)	DIDELPHIDÆ.	DASYURIDÆ.			MYRMECOBIDÆ.	PERAMELIDÆ.		MACROPODIDÆ.		PHALANGISTIDÆ.			PHASCOLOMIDÆ.	DIPODIDÆ.	AMOUNT OF ALL MARSUPIALIA.
	Didelphys (Opossum.)	Thylacinus.	Dasyurus.	Phascogale.	Myrmecobius.	Perameles.	Chæropus.	Macropus (Kangaroo.)	Hypsiprymnus.	Phalangista (Flying-pt.)	Petaurus.	Phascolarctus (Koala.)	Phascolomys (Wombat.)	Dendrolagus.	
OLD WORLD.	*N*	*u*	*m*	*b*	*e*	*r*	*of*	*S*	*p*	*e*	*c*	*i*	*e*	*s.*	
Asiatic Archipelago, comprising the Islands of Java, Celebes, Timor, Ceram, Amboina, Banda, and Waigiou,	.	.	.	.	.	.	.	1	.	4	.	.	.	.	5
New Guinea and New Ireland,	.	.	.	1	.	1	.	1	.	2	.	.	2	.	7
North and north-east coast of Australia, from Port Essington to Barrow Island,	.	.	.	.	.	.	.	5	.	.	.	.	.	.	5
West Australia, from Shark's Bay to King George's Sound,	.	.	.	2	2	3	.	12	6	.	.	.	.	.	25
New South Wales, and generally south-east Australia, from 30° south latitude to Spencer Gulf,	.	.	2	3	.	2	1	15	5	3	6	1	1	.	39
Van Diemen's Land, and the Islands in Bass' Strait,	.	1	4	1	.	2	.	3	.	2	Norfolk Island 1 Species.	.	1	.	17
NEW WORLD.															
North and Central America, and the Antilles,	4	.	.	.	.	.	.	.	.	.	.	.	.	.	4
Guayana,	6	.	.	.	.	.	.	.	.	.	.	.	.	.	6
Brazil,	9	.	.	.	.	.	.	.	.	.	.	.	.	.	9
The northern and western parts of South America, comprising Venezuela, New Granada, Ecuador, Peru, and Bolivia,	2	.	.	.	.	.	.	.	.	.	.	.	.	.	2
The southern parts of South America, from the Tropic of Capricorn to 30° south latitude, comprising Chile, La Plata, Paraguay, and Uruguay,	6	.	.	.	.	.	.	.	.	.	.	.	.	.	6

DISTRIBUTION OF THE SINGLE FAMILIES.

1. *Didelphidæ.* This is the only family found in the New World, and, as shown on the map, the district over which it is distributed is more extensive than that of any family of the Old World. *Didelphys virginiana* (Virginian opossum) extends from the southern limits of Canada, through the United States and Mexico to the Antilles, where it is called manita. According to Pennant, it is also found in Peru and Brazil. This is the largest species of the family, and attains to about the size of a cat. The other species are generally so small that they might, by a common observer, be mistaken for rats or mice, were it not for their elongated and pointed muzzle. *Didelphys dorsigera*, found in Surinam, derives its name from the habit of carrying its young on its back. In place of the usual pouch, the females have a fold in the skin of the belly, which may be regarded as a rudimentary pouch. When old enough to leave the teats, the young are carried on the back of the parent, where they maintain themselves by entwining their prehensile tails round that of the mother. On the western side of the Andes, marsupial animals appear to be very uncommon, since only one species, *Didelphys elegans* (elegant opossum) has yet been observed; it was discovered by Mr Darwin, in the neighbourhood of Valparaiso, where he says they "frequent thickets growing on the rocky hills," and are exceedingly numerous. One species lives in the water, and appears to resemble the otter in its habits. It constitutes the genus *Chironectes* of Illiger; but Mr Waterhouse says it should be regarded as a sub-genus of the *Didelphys*. This species is found in all the smaller streams of Brazil, and extends from the southern border of that empire to the shores of the Gulf of Honduras.

2. *Dasyuridæ.* As shown by the lines on the map, these animals are limited to the countries of New South Wales and Van Diemen's Land, with the exception of one single species, which is found in New Guinea. They do not live upon trees, like most of the true oppossums, but hide themselves in holes or in crevices of the rocks during the day, and at night prowl about like weasels in search of their prey. The *Thylacinus* inhabits only Van Diemen's Land, "where it is called the tiger-hyæna, and used formerly to be known among the colonists by the names, zebra-opposum, and zebra-wolf." The most ferocious of all the species is *Dasyurus ursinus* (ursine dasyurus), which is an inhabitant of Van Diemen's Land, and is called by the colonists the native devil. It is a voracious feeder, and is described as the most destructive of all the indigenous quadrupeds. The *Phascogales* are the smallest animals of the family of the Dasyuridæ, being commonly about the size of a rat. They occur throughout the colony of New South Wales, and have been found at Adelaide, in South Australia. Solomon Müller discovered a species of this genus in New Guinea, which was distinguished from all the others by the blackness of its fur.

3. *Myrmecobiidæ.* This beautiful and interesting little animal, which is about the size of a squirrel, was discovered by Lieutenant Dale, in the Swan River settlement, about ninety miles to the south-east of the Swan River.

4. *Peramelidæ.* The district of distribution of these animals extends from New Guinea to Van Diemen's Land. They feed on insects and vegetable substances. That discovered by Major Mitchell, at the River Murray, and described by Ogilby, genus *Chæropus*, differs from the *Perameles* in the absence of a tail, and in the form of its fore feet, which strongly resemble those of the genus sus (swine).

5. *Macropodidæ* (the Kangaroos). These animals, as Mr Waterhouse observes, "are remarkable for the flexibility and lightness of the anterior parts of the body, the smallness of the anterior members, and the great size of the posterior extremities, and of the tail." The young, when first produced, are imperfect in their development, and not larger than a mouse. By some unknown means, they are conveyed to the external pouch, where they remain firmly attached to the nipple till their development is perfected, and till they have increased greatly in size. The kangaroos have the greatest number of species of any family of the order, having not fewer than forty, or about one-third of all the species of Marsupialia. They are also the most widely distributed of any family in the Old World, since they occur in all hitherto discovered parts of Australia and New Guinea, and according to Le Brun are found also in the Island of Java. One of the most beautiful animals of the genus macropus, the proper kangaroos, is *Macropus fasciatus* (the banded kangaroo). It is about the size of a rabbit. Its habitat is on the islands in Shark's Bay, on the west coast of Australia, and it appears not to occur on the mainland.

6. *Phalangistidæ.* All the phalangers are nocturnal in their habits; they live in trees, and are expert climbers. Of all the Marsupialia which inhabit the islands of the Asiatic Archipelago and New Guinea, three are the most numerous and common, and they are the only ones which inhabit the island of Celebes. The beautiful species *Phalangista maculata* (the spotted phalanger) is distributed, as will be seen by the limits on the map, over the islands of New Guinea, Ceram, Amboina, Banda, and Timor. This species is also represented among the typical figures. The genus *Petaurus* occurs only in New South Wales, at least, as already mentioned, it is uncertain whether it is also found in Norfolk Island. The genus *Phascolarctos*, which possesses only the single species *Phascolarctus fuscus* (the koala), is likewise limited to New South Wales.

7. *Phascolomidæ.* This family, which includes the wombat (Phascolomys wombat), possesses only one species; it is found in the colony of New South Wales, South Australia, and Van Diemen's Land, as well as in some of the islands of Bass' Strait.

8. *Dendrolagidæ.* The only known species of this family, as already mentioned, was discovered by Salomon Müller in the western district of New Guinea.

THIRD SECTION.

DIVISION AND DISTRIBUTION OF THE *EDENTATA (TOOTHLESS ANIMALS).*

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The Edentata, that strange assemblage of animals which, on account of their defective system of teeth, have all been classed in one order, contain only twenty-eight species, forming one-fifty-fourth of all Mammalia. These form the following eight genera:—

NEW WORLD.	No. of Species.	OLD WORLD.	No. of Species.
1. Bradypus, { Bradypus tridactylus or ochrus (ayes) . . . sloths,	2	5. Oryctoropus (African ant-eater) . .	1
{ Bradypus didactylus or cholœpus (unau) . .	2	6. Manis (pangolin)	4
2. Dasypus (armadill	11	7. Echidna, tachyglossa (porcupine ant-eater)	2
3. Chlamyphorus (pichie)	1	8. Ornithorynchus	1
4. Myrmecophaga (American ant-eater) . .	4		

The Edentata inhabit chiefly the countries of South America, where, as the preceding table shows, there are nearly three times as many species as are found in Asia, Africa, and Australia, together. They extend farthest towards the north in the Old World, namely, to about 27° 30′ north latitude, in Nepaul. In the Southern Hemisphere, they extend about 16 degrees farther from the equator, in the New as well as in the Old World. In the former they are found in the plains of Patagonia, and in the latter at the southern point of Van Diemen's Land.

DIVISION AND INTENSITY OF THE SPECIES.

As already observed, the New World is the proper country of the Edentata, and here they are not, as in the case of the monkeys and pouched animals, limited, in general, to tropical America, since they extend to the plains of Patagonia, where the annual mean temperature corresponds with that of the south of England. In the whole of South America, from the Tropic of Cancer southwards, especially in the great plains of the pampas the Edentata are the most numerous of all Mammalia, and are the characteristic animals of those countries; the *Chasypus*, which is the smallest of all the Edentata, is characteristic of this region; in consequence of which the intensity of the species is pretty equally distributed over the countries from Guayana to La Plata. In Asia, Africa, and Australia the occurrence of the Edentata is only occasional; wide spaces separate the genera which are poor in species; yet it contains one of the most singular of all Mammalia namely, the ornithorynchus.

TABLE SHOWING THE DIVISION OF *EDENTATA (TOOTHLESS ANIMALS)* OVER THE GLOBE, ACCORDING TO THE NUMBER OF THEIR SPECIES.

REGIONS & COUNTRIES.	Bradypus (Sloths.)	Dasypus (Armadillos.)	Chlamyphorus (Pichiciago.)	Myrmecophaga (Am. Ant-eater.)	AMOUNT OF ALL SPECIES.
NEW WORLD.	*Num*	*ber of*	*Spe*	*cies.*	
Central America, from the southern limits of Mexico; New Granada, Venezuela and Guayana,	3	7	.	2	12
Brazil to the Tropic of Capricorn,	3	8	.	3	14
From the Tropic of Capricorn to the Patagonian Plains, about 42° s. lat.) including Paraguay, La Plata, Chile, and Patagonia	.	3	1	2	12

OLD WORLD.	Orycteropus (African ant-Eater.)	Manis (Pangolins.)	Echidna s. Tachyglossa (Porcupine ant-eaters.)	Ornithorynchus.	AMOUNT OF ALL SPECIES.
Asia,	.	2	.	.	2
Africa,	1	2	.	.	3
Australia	.	.	2	1	3

NEW WORLD.

1. *Bradypus* (sloths). The district of these animals extends from the southern limits of Mexico to Rio de Janiero, including Central America, New Granada, Venezuela, Ecuador, Guayana, and Brazil, to the eastern declivity of the Andes, where the primitive forests, to a height of about 3,000 feet, in the regions of palms and scitamineæ, are inhabited by these slow and unwieldy animals. *Bradypus tridactylus s. ochrus* (three-toed common sloth or ayes) has the widest district of any of the species, since it extends from Honduras to Brazil, in about latitude 17° 20′ south; whilst *Bradypus didactylus s. cholœpus* (unau) the larger species, is found only in Guayana.

2. *Dasypus* (armadillos). Like the sloths, the armadillos are peculiar to the New World, and no similar animals are found in any other part of the globe. They extend from the banks of the Orinoco, through the whole of South America, and form the southernmost limits of American Edentata; they live in the plains as well as on the table-lands, and occupy the lower regions of the Andes to the same height as the sloths. The number of species increases from north to south, and attains its maximum in the plains and pampas of Paraguay and La Plata. *Dasypus tolypeutes* (one-handed armadillo) occurs only in Chile, La Plata, and Paraguay. It has the power of rolling itself like a ball, and has hence been considered by some naturalists as a separate genus. *Dasypus pebo* (tatouhew, or nine-banded armadillo). This species, of which we have given a representation, is distributed over the countries of South America, from Guayana to Paraguay, in the former of which it is very common. It is never found in the woods, but frequents the open cultivated plains; and is much hunted by the inhabitants on account of its flesh, which, when roasted in the shell, is said to be extremely delicate. This is one of the smallest of the armadillos. The largest *Dasypus giganteus s. gigas* (giant, or great armadillo) is more than three feet long. Its district extends from Guayana, Brazil, and the northern part of Paraguay to Assumption. As the previously mentioned species never inhabits the woods, so, on the contrary, this is never found in the open country, but keeps in the close vicinity of the great forests.

The remaining species almost all inhabit the same district, which extends over Guayana, Brazil, and Paraguay. *Dasypus vardaleiro* (vardaleiro armadillo) is found only in Brazil, and *Dasypus sgmaurus* only in Paraguay.

3. *Chlamyphorus* (pichiciago). This extraordinary little creature, scarcely six inches in length, is formed on a plan which combines the utmost strength and solidity. It is a native of Chile and La Plata, but is so rare that it is regarded by the natives as a curiosity.

4. *Myrmecophaga* (American ant-eaters). These animals do not extend so far towards the south as the armadillos, since they are not found beyond Buenos Ayres. *Myrmecophaga jubata* (the great ant-eater or ant-bear) is characterized by the total absence of teeth, by a narrow head, and an extremely slender elongated snout. This is the largest of all toothless animals. It feeds almost entirely on insects, especially, as its name implies, on ants. *Myrmecophaga didactyla* (the little ant-eater). This species which, as shown in the drawing, differs so completely in size and form from the former one, is found only in the forests of Guayana and Brazil.

two American species, *Tapirus Americanus* (the common American tapir) is distributed over the countries from Nicaragua, about latitude 14° north, to the pampas of La Plata, about latitude 40° south. It ascends the Andes to as great a height as the peccaries. The second species, *Tapirus pinchaque*, which was only lately discovered, inhabits chiefly the most elevated parts of the Andes of New Granada.

9. *Equus* (horse). The animals of this genus are very characteristically divided into three principal groups:—1st, Group of the *proper horses*; 2d, *Asinine group* (asses); 3d, *Hippotigrine group* (zebras). These animals, in a domesticated, as well as in a wild state, are distributed over the whole globe. In our map the first group is entirely omitted, in order to admit of greater clearness in the representation of the other genera of the Pachydermata. Besides, it would have been impossible clearly to separate the distribution of the original wild horse from the feral, or that which had once been domesticated, but has again returned to a state of nature.[1] On the contrary, the second group, that of the wild ass, which is characteristic of the great highlands and deserts of the interior of Asia; and the third group, that of the zebra, which is peculiar to Africa, have their limits so fixed by nature, as to admit of being delineated on the map with considerable minuteness. The wild asses, which, on the map, are all comprehended under the species *Equus asinus onager*, and are included within the same boundaries, extend over the countries from Siberia to Egypt. There prevails, however, a great confusion among the different species, occasioned by the great number of names which are applied to them; and on this account it is often difficult to decide whether two supposed species are the same animal under different names, or, if different, in what the difference consists, or even whether a particular species belongs to the horse or the asinine group. On this account we have only given the names of those which are well known in the countries where they occur. *Koulan* (the wild ass of the Tartars), which is regarded as the origin of the common ass, inhabits the dry mountainous parts of Great Tartary, where, in summer, it ranges as far as latitude 48° north, returning southward with the change of season. Whole herds of them may be seen in motion as far as the deserts of the Lower Indus; but they are distributed chiefly over the eastern provinces of Persia. *Equus asinus hemionus* (djiggetai of the Mongols) *Mulus, dauricus, cappadocius*, Kitchera, extends northwards into southern Siberia, and is spread over the Desert of Gobi. It is abundant in Thibet, and in the regions of the Himalayan Mountains, and is not unknown in India, unless it is there perhaps confounded with the *Asinus equuleus*. *Equus asinus equuleus* (yo-to-tze of the Chinese?) is said to have been brought from the Chinese frontiers north-east of Calcutta; and to inhabit different parts of Chinese Tartary, but very little is known of its distribution. The principal remaining species are, the *ghoor-khur* of Afghanistan and the banks of the Indus and Persia, where it is confounded with the hamar or ahmar (djar of the Arabs and Mograbins, and daja-ischake of the Turks); the *Equus kiang* of the Himalayan Mountains, discovered and named by Moorcroft. The wild ass of Cutch and northern Gujerat, which Colonel Sykes identifies with the djiggetai and ghoor-khur, is not found farther eastward than longitude 75°, on the southern side of the Himalayan Mountains; it especially frequents the salt deserts and open plains of Jodhpoor, Jaysulmeer, and Bickaneer.

Of the zebras, some of which prefer mountainous districts, and others the upland plains, the first species, *Equus zebra s. montanus* (zebra), extends from the territory of the Cape of Good Hope northeastward, beyond the country of Mozambique, probably as far as the southern mountains of Abyssinia; it occurs also in Congo and Guinea. *Equus burchellii* (hippotigris antiquorum—douw of the South African colonists), is an inhabitant of the plains, and occurs in every district north of the River Gariep, extending probably from Congo eastwards to the Galla country. It is especially abundant in the province of Rumba, in Congo. *Equus quagga* (the quagga) is a native of the plains, and is found to the south of the Gariep River, within the limits of the Cape Colony

[1] It is well known that the horses of Texas, Cuba, S. Domingo, and the pampas of La Plata, in the New World; and those of the western coast of Africa, Celebes, &c., in the Old World, introduced to these countries in a domesticated state by the original colonists or conquerors, have, when left to spread themselves over uninhabited districts, returned to the wild state.

ZOOLOGICAL GEOGRAPHY.

SHEET No. II.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION OF MAMMIFEROUS ANIMALS,

OF THE ORDER

CARNIVORA (CARNIVOROUS ANIMALS).

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SECTION I.

CLASSIFICATION AND GENERAL REMARKS ON DISTRIBUTION.

The animals treated of in this section have, in all ages, been objects of peculiar interest to mankind, sometimes on account of their strength, magnanimity, and valour, but more frequently because of their cruelty, their cunning, and their blood-thirsty habits.

The term Carnivora, in zoology, is used generally to designate all creatures that feed on flesh or animal substances; but it is more especially applicable to that order of mammiferous quadrupeds which feed on other animals, and to which Cuvier has given the name of Carnassiers (flesh-eaters).

This order is divided into the following families:—

1. Chiroptera.
2. Dermoptera.
3. Insectivora.
4. Plantigrada.
5. Digitigrada.
6. Pinnipedia.

The sixth family, that of the *Pinnipedia*, comprising the genera *Phoca* and *Trichechus* (seals and morses) whose habitat is in the sea, is excluded from this section, which treats of the first five families comprising the Land-Carnivora. According to the latest authorities, and the most careful calculations, these five families contain, in all, 514 known and described species, forming one-third of all Mammalia. These 514 species are divided into 61 genera, in the following manner:—

	Number of Species.
I. CHIROPTERA,	**219**
A. FRUGIVORA (FRUGIVOROUS BATS).	
1. Pteropus (Roussette Bats),	20
2. Pachysoma (Stout-bodied Roussettes),	6
3. Macroglossus (Great-tongued Roussettes),	1
4. Harpyia (Tube-nosed Roussettes),	1
5. Cephalotes (Cephalotes),	1
B. INSECTIVORA (INSECTIVOROUS BATS).	
6. Dysopes (Bull-dog Bats),	17
7. Diclidurus (Fox-tailed Bats),	1
8. Noctilio (Hare-lipped Bats),	2
9. Vampyrus (Vampyre Bats),	1
10. Phyllostoma (Javelin Bats),	13
11. Glossophaga (Long-tongued Bats),	4
12. Megaderma (Broad-winged Bats),	3
13. Rhinolophus (Horse-shoe Bats),	29
14. Nyctophilus (South-Sea Bats),	1
15. Nycteris (Cheek-pouched Bats),	6
16. Desmodus (Curved-tooth Bats),	3
17. Rhinopoma (Lid-nose Bats),	1
18. Taphozous (Wing-pouched Bats),	9
19. Mormoops (Mormoops Bats),	1
20. Emballonura (Long-nosed Bats),	5
21. Nycticejus (Round-flap Bats),	11
22. Vespertilio (Bats proper),	81
23. Furia (Fury Bats),	1

	Number of Species.
II. DERMOPTERA,	**3**
24. Galeopithecus (Vaulting or Flying Cats),	3
III. INSECTIVORA,	**61**
25. Erinaceus (Hedgehogs),	5
26. Sorex (Shrews),	26
27. Hylogale (Huxstings),	4
28. Hylonyx (Hylonyx),	1
29. Gymnura (Oriental Hedgehogs),	1
30. Myogale (Desmans),	2
31. Scalops (Scalopes),	1
32. Macroscelides (Cape-Elephant Shrews),	5
33. Chrysochloris (Chrysochloris),	4
34. Centetes (Tenrecs),	4
35. Talpa (Moles),	4
36. Condylura (Condylures or star-nosed Moles),	4
IV. PLANTIGRADA,	**38**
37. Ursus (Bears),	12
38. Procyon (Racoons),	2
39. Ailurus (Panda),	1
40. Nasua (Coatis),	6
41. Arctitis (Bentturongs),	4
42. Cercoleptes (Kinkajous or Potos),	2
43. Meles (Badgers),	2
44. Gulo (Gluttons),	5

	Number of Species.
V. DIGITIGRADA,	**193**
45. Mustela (Martens),	28
46. Mydaus (Teledus, Telagius, or Stinkards),	2
47. Mephitis (Skunks),	15
48. Lutra (Otters),	17
49. Canis (Dogs),	41
50. Viverra (Civets),	15
51. Cryptoprocta (Cryptoproctes),	1
52. Potamophilus (Potamophiles),	1
53. Linsang (Linsangs or Dobundangs),	1
54. Paradoxurus (Paradoxures),	4
55. Herpestes (Ichneumons),	10
56. Hyaena (Surinates),	2
57. Proteles (Proteles),	1
58. Cynictis (Cynictis),	1
59. Bassaris (Bassaris),	1
60. Hyaena (Hyaenas),	4
61. Felis (Cats),	54

From the presence of carnassiers, or flesh-eaters, in any particular region or quarter of the globe, we may conclude the prevalence of the weaker classes of animals, since it is from the latter chiefly that they derive their nourishment; and a simple inspection of the map will show that the great seat of the carnivorous tribe is in the tropical regions, thus confirming the general law referred to in the notes to the first sheet of this division, namely, that animal formations increase in proportion as we advance from the arctic and temperate regions of the globe towards the equator. But this general law is reversed, as already mentioned, in the case of the marine Mammalia, or animals of higher organization which inhabit the sea, since these are found to decrease in proceeding from the arctic to the tropical regions; and even in the case of the Land-Carnivora this law suffers a remarkable exception; for there is a region within the tropics which is characterized by a great deficiency in animals of the carnivorous order: this is the Oceanic province, which embraces New Guinea and the adjacent islands.

In the same longitude, and chiefly within the tropics, is situated the Australian region, which, as containing the minimum number of Carnivora, is distinguished by the lightest shading on the map, a reference to which will show the remarkable contrast which it forms with the regions of Africa and South America, situated in the same parallel of latitude.

In so far as ascertained, animals of the order Carnivora are spread over the whole globe—their occurrence has no limits, but their distribution among the different countries and regions is very irregular. This will be best understood by a reference to the following arrangement:—

DIVISION OF THE GLOBE INTO ZOOLOGICAL KINGDOMS AND PROVINCES.

The surface of the globe may be arranged in certain zoological kingdoms, and these may again be subdivided into provinces, as has been done by Zimmerman, Illiger, Minding, and latterly by Swainson and Schlegel. Following this example, we shall divide the earth into *five* great zoological kingdoms, which correspond in extent with the five principal divisions of the globe.

1. The *first* kingdom embraces Europe, which is divided into the Northern, Middle, and Southern provinces. The limit between the Northern and Central provinces falls about latitude 60° north, or more accurately, it coincides with the curve of 61° mean annual temperature. The separation between the Central and Southern provinces is formed by the chains of the Pyrenees and the Alps; the peninsulas of Spain, Italy, and Greece, with the islands of the Mediterranean, form the Southern province, which, in the East, is divided by the Ural Mountains from the

2. *Second* kingdom, comprising Asia. At the junction of Europe and Asia, on the coasts of the Black Sea and the Caucasus, the European and Asiatic forms of animals are mixed, and pass into each other. There is here a peculiar zoological district, consisting of Anterior Asia, or the countries of the Caucasus, Asia Minor, Syria, and the table-lands of Iran (Persia), which we have designated by the name of the European-Asiatic Transition province, in which are also found specimens of the zoological characters of Africa. Asia is divided also into three provinces—the Northern, Middle, and Southern. The Northern province extends from the Volga in the west, to the mountain range of the Altai, with a mean temperature of 42°; and eastward to the shores of the Pacific Ocean, where it is bounded by the isotherm curve of 32°, which marks the limit of the permanent frost of the ground. This province includes the whole of Siberia, Kamtschatka, &c. The Central province is limited on the south side by the Himalayan Mountains, consequently it comprises all Asia, from the Caspian Sea to the Pacific Ocean including the islands of Japan, &c. Beyond the Himalaya begins the Southern province, or the Indian world, comprising both peninsulas, a part of the Southern province of China, and the whole Archipelago. The south-eastern extremity of the zoological region of Asia is so strictly defined by the Moluccas and Timor, that whilst on these islands there is a great abundance of Carnivora and other orders of animals, on New Guinea, separated from them only by a small arm of the sea, they appear to be almost or entirely wanting. We have now reached the Oceanic province, already mentioned as being characterized by a great deficiency of carnivorous animals; southward from it lies the

3. *Third* zoological kingdom, or Australia, which, besides the continent of Australia and Van Diemen's Land, comprises the islands to the eastward, including New Zealand, and the numerous small groups of Polynesia; and these, from the small extent of space to which they are confined, the uniformity of the soil, climate, and produce, and the consequent uniformity of the animal world, form only one province.

4. The *fourth* kingdom consists of Africa, the peninsula of Arabia, which in its natural character is so closely connected with it, and the islands of Madagascar, Bourbon, and Mauritius.

5. The *fifth* kingdom consists of North and South America, or the New World, and is divided into four provinces, namely, those of Arctic, Northern, Tropical, and Southern America. The Arctic is divided from the Northern province by a curved line beginning about Prince of Wales Island, on the west, and passing eastward through the middle of the Canadian lakes; this line coincides with the isotherm curve of 46°, and the province is chiefly composed of British, and Russian America. The Northern province extends southward to the Gulf of Mexico, whence it is bounded by a line drawn from the mouth of the River Bravo del Norte to the northern extremity of the Gulf of California, and comprises the United States, Texas, and the greater part of Mexico. The Tropical province extends through Central America, the Antilles, and all South America, to the parallel of 40° south, where it is joined by the Southern province, which comprises Patagonia and the islands south to Cape Horn.

ZOOLOGICAL GEOGRAPHY.

SHEET № 2

GEOGRAPHICAL DIVISION & DISTRIBUTION OF CARNIVORA (CARNIVOROUS ANIMALS)

FROM THE LATEST AUTHORITIES

BY A.K. JOHNSTON, F.R.G.S.

FAMILIES & GENERA OF THE LAND CARNIVORA

EXPLANATION

of the Colours in the Map, and of the Abbreviations in the small synopt. tables.

I. Chiroptera
a Frugivora
1 Pteropus
2 Pachysoma
3 Macroglossus
4 Harpyia
5 Cephalotes
b Insectivora
6 Pteropus
7 Dicliduras
8 Noctilio
9 Vampyrus
10 Phyllostoma
11 Glossophaga
12 Megaderma
13 Rhinolophus
14 Nycteophilus
15 Nycteris
16 Rhinolophus
17 Rhinopoma
18 Taphozous
19 Mormopterus
20 Emballonura
21 Nycticejus
22 Vespertilio
23 Furia
II. Dermoptera
24 Galeopithecus
III. Insectivora
25 Erinaceus
26 Sorex
27 Hydrogale
28 Hydromys
29 Gymnura
30 Myogale
31 Scalops
32 Macrorhinclides
33 Chrysochloris
34 Centetes
35 Talpa
36 Condylura
IV. Plantigrada
37 Ursus
38 Procyon
39 Ailurus
40 Nasua
41 Arctitis
42 Cercoleptes
43 Meles
44 Galo
45 Mustela
46 Mydaus
47 Mephitis
48 Lutra
49 Lutis
50 Viverra
51 Cryptoprocta
52 Putamophilus
53 Linsang
54 Paradoxurus
55 Herpestes
56 Ryzaena
57 Proteles
58 Cynictis
59 Bassaris
60 Hyæna
61 Felis
V. Digitigrada

Probable Equatorial Limit of Ursus maritimus

Limit of Ursus maritimus

(Polar Bear — White Bears of the Icy Sea)

(Glutton)

Polar limit of GENUS FELIS

Polar Limit of GENUS FELIS

Common Wolf

Limit of Forests

American Wolf

Polar limit of GENUS FELIS

C. lupus occidentalis (American Wolf)

Ursus ferox (Grizzly Bear)

Prairie Wolf

Limit of Forests

American Wolf

Northern limit of Procyon lotor (Raccoon)

Sciuropterus Condeanus (Arctic Flying Squirrel)

Sorex Condeanus (Shrew Mole)

Condylures

American Wolf

South limit of Canis lagopus (Arctic Fox)

Procyon lotor (Raccoon)

N. limit of Sciuropterus Volucella (Arctic Flying Squirrel)

Northern limit of Mephitis Bivirgata

N. limits of Mephitis Bivirgata and Condylura Cristata

N. limit of the FAMILY CHIROPTERA

Canis Vulpes Lupus Chacal Rhinolophus

Talpa Europ. (Common Mole)

Occasional N. extension of the Tiger

Panther

Common Wolf

Tiger

Lion

Hyæna striata (Striped Hyæna)

Hyæna fusca (Brown Hyæna)

Felis Tigris (Royal Tiger)

Felis Leo (Asiatic Lion)

Himalaya

Pteropus Javanicus (Javan Flying Fox)

Rhinol. hirsutus (Horned Horse-shoe Bat)

Pteropus Edwardsii (Woolly Roussette)

Rhinol. hirsutus (Horned Horse-shoe Bat)

Pteropus urvinus (Urvine Roussette)

Pteropus Tubaiae (Maned Roussette)

Pteropus Keraudrenius (Keraudren's Roussette)

Galeopithecus (Flying Cat)

GENUS FELIS

Pteropus Pselaphon (Large-eared Roussette)

Pteropus Capistratus (Capistrate Roussette)

Pteropus Pilosus (Hairy Roussette)

Pteropus Pilosus (Hairy Roussette)

Pteropus Pilosus (Hairy

SCALE OF INCREASING DENSITY OF CHIROPTERA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
3.	Southern America,	1
12.	Arctic America,	1
1.	Australia,	3
14.	Arctic Asia,	6
13.	Arctic Europe,	7
8.	Transition Province,	7
11.	North America,	10
7.	Central Asia,	12
10.	Central Europe,	20
9.	Southern Europe,	22
2.	Oceanic Province,	25
5.	Tropical Africa,	41
4.	Tropical America,	55
6.	Tropical Asia,	67

II. FAMILY DERMOPTERA.

As has been already remarked, the animals belonging to this family are restricted to a single province—that of Tropical Asia.

III. FAMILY INSECTIVORA.

The Insectivora differ from all the other families in this respect, that they do not follow with such regularity the general law, according to which the greatest numbers should be found under the tropics; for in the Tropical province of America only four species occur, whilst in the Temperate province there are eight, and in the Arctic province seven species. In the Old World they follow the general law of density in tropical climates, but differ from the other families in having the greatest number of species in Tropical Africa, whilst the maximum of all the others occurs in Tropical Asia.

The most extensive genus of the Insectivora, the *shrews*, has also, like the genus vespertilio in the family of Chiroptera, the widest circle of distribution; since, with the exception of the Austral provinces, it is found in all the zoological provinces, and is especially numerous in Africa and Asia. The moles and hedgehogs are also distributed over one-half of all the provinces.

SCALE OF INCREASING DENSITY OF INSECTIVORA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
1. 2. 3.	Austral Provinces,	0
13.	Arctic Europe,	3
8.	Transition Province,	4
4.	Tropical America,	4
14.	Arctic Asia,	6
9.	Southern Europe,	6
12.	Arctic America,	7
11.	North America,	8
10.	Central Europe,	10
7.	Central Asia,	11
6.	Tropical Asia,	15
5.	Tropical Africa,	25

IV. FAMILY PLANTIGRADA.

This family restores the general balance in the distribution of species, which was disturbed by the three previous families: since Africa, which contains the greatest number of Insectivora, has, of all the provinces, the fewest Plantigrada. There is one remarkable feature in their distribution, namely, that Africa, together with Europe, under the same longitude, contains, in comparison with the other parts of the earth, the fewest species of Plantigrada, and that here, instead of increasing in the direction of the equator, they are found to increase towards the poles. This arises from the genus of the proper bears, whose habitat is confined chiefly to the frigid zone. The *Asiatic* world and America nearly resemble each other in the distribution of species; but Tropical and Central Asia are especially rich in species of the genus ursus.

SCALE OF INCREASING DENSITY OF PLANTIGRADA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
1. 2. 3.	Austral Provinces,	0
9.	Southern Europe,	2
5.	Tropical Africa,	2
10.	Central Europe,	3
8.	Transition Province,	4
13.	Arctic Europe,	4
14.	Arctic Asia,	5
11.	North America,	5
12.	Arctic America,	5
7.	Central Asia,	7
6.	Tropical Asia,	11
4.	Tropical America,	12

V. FAMILY DIGITIGRADA.

This last family, although not quite so numerous as that of the Chiroptera, is the most important since it contains the most powerful and ferocious of all carnivorous animals. It is distributed throughout all the zoological provinces, although by far the greater number occurs in the countries under the tropics, whence it gradually decreases, both in the number of species and the size of individuals, in the direction of the poles. In the New World, however, this gradual decrease towards the poles is more regular than in the Old World, where, in Africa, there are 62, and in Southern Europe only 12 species, being five times more numerous in the former than in the latter country, in equal latitudes. In Tropical Asia there are 68, and in Central Asia 23 species; or nearly *three times* more in the former than in the latter province.

Canis and *Felis* (the dog and cat tribes) are the two most important and numerous genera of the Digitigrada, and have also the widest circle of distribution, although the two provinces of Australia and Oceania do not possess a single species of the genus felis, and only one species of the genus canis, which, with one species of the genus paradoxurus, is the only species of the Digitigrada found in these provinces. Next to these the genera of the martens and otters are distributed over the greatest number of provinces, the former especially in the temperate, and the latter in the torrid zone.

SCALE OF INCREASING DENSITY OF DIGITIGRADA IN THE FOURTEEN ZOOLOGICAL PROVINCES.

No. of Province.		Species.
1.	Australia,	1
2.	Oceanic Province,	2
3.	South America,	12
9.	Southern Europe,	12
10.	Central Europe,	13
13.	Arctic Europe,	17
14.	Arctic Asia,	19
12.	Arctic America,	23
8.	Transition Province,	25
7.	Central Asia,	25
11.	North America,	27
4.	Tropical America,	38
5.	Tropical Africa,	62
6.	Tropical Asia,	68

DIVISION OF THE GENERA IN THE OLD AND NEW WORLD.

Of the 61 genera of the Land-Carnivora very few are peculiar to either the Old or the New World as a whole, but many belong exclusively to the single provinces; thus we find that 28 of them, or nearly one-half of their number, are chiefly characteristic of the three Tropical provinces. We have prefixed a small asterisk (*) to the name of each of those in the table, page 2, which renders an enumeration of them here unnecessary. If we investigate the manner in which the Carnivora are divided in the Old and the New World, we shall find that only 17 genera belong in common to both hemispheres, and that of the remaining 44, 14 characterize the New, and 30 (or double the number) characterize the Old World. On examining the table, we find that those genera which are common to both hemispheres are distinguished by the number of their species, that those 17 genera contain 333 species, or nearly twice as many as the remaining 44 genera, which have in all only 181 species. In regard to the single families, we see that of all the Digitigrada hardly a single genus is peculiar to the New World; for the insignificant genus *Bassaris*, containing only one species, is not worth reckoning, whilst 11 genera, comprising 42 species, are peculiar to the countries of the Old World.

TABLE SHOWING THE DISTRIBUTION OF THE GENERA IN THE OLD AND NEW WORLD.

GENERA PECULIAR TO THE OLD WORLD.	GENERA PECULIAR TO THE NEW WORLD

I. CHIROPTERA.

A. FRUGIVORA.

	Number of Species.		Number of Spec.
1. Pteropus	30		
2. Pachysoma,	6		
3. Macroglossus,	1		
4. Harpyia,	1		
5. Cephalotes,	1		

B. INSECTIVORA.

12. Megaderma,	3	7. Diclidurus	1
15. Rhinolophus,	20	8. Noctilio,	1
16. Nycteribia,	1	9. Vampyrus,	1
18. Nycteris,	6	10. Phyllostoma,	3
17. Rhinopoma,	1	11. Glossophaga,	1
		16. Desmodus,	1
		19. Mormoops,	1
		23. Furia,	1

II. DERMOPTERA.

24. Galeopithecus,	5		

III. INSECTIVORA.

27. Hylogale,	4	31. Scalops,	1
28. Hylomys,	1	36. Condylura,	1
29. Gymnura,	1		
30. Myogale,	2		
32. Macroscelides,	5		
34. Centetes,	4		

IV. PLANTIGRADA.

39. Ailurus,	1	28. Procyon,	2
41. Arctitis	4	40. Nasua,	6
		42. Cercoleptes,	2

V. DIGITIGRADA.

46. Mydaus,	2	59. Bassaris,	1
50. Viverra,	15		42
51. Cryptoproeta,	1		
52. Palamophilus,	1		
53. Lissnag,	1		
54. Paradoxurus,	6		
55. Herpestes,	10		
56. Rynema,	2		
57. Proteles,	1		
58. Cynictis,	1		
60. Hyæna,	4		
	139		

GENERA WHICH ARE COMMON TO THE OLD AND THE NEW WORLD.

I. CHIROPTERA.

B. INSECTIVORA.

	Number of Species.
*6. Dysopes.	17
18. Taphozous,	9
20. Emballonura,	5
21. Nyctiecjus,	11
22. Vespertilio,	81

III. INSECTIVORA.

25. Erinaceus,	5
26. Sorex,	26
33. Chrysochloris,	4
35. Talpa,	4

IV. PLANTIGRADA.

37. Ursus,	12
43. Meles,	3
44. Gulo,	5

V. DIGITIGRADA.

45. Mustela,	28
47. Mephitis,	15
48. Lutra,	17
49. Canis,	41
61. Felis,	51
	333

DISTRIBUTION OF THE SINGLE GENERA AND SPECIES.

I. FAMILY CHIROPTERA.

As shown in the preceding section, the Chiroptera are spread over all the provinces; but of the two subdivisions, the frugivorous bats occur only in the Old World, whilst the insectivorous bats, although common to the Old are more characteristic of the New World.

A. FRUGIVORA (FRUGIVOROUS BATS), so named from the circumstance of their feeding almost exclusively on fruits, have a district extending from Africa on the west, over Madagascar, Bourbon, Mauritius, India, and the Indian Archipelago, to Australia and Van Diemen's Land on the east; and over the Pacific Ocean, from the Friendly Islands in the south, to Japan on the north.

1. *Pteropus* (roussette bats). These have the widest district of distribution of any of the five genera which belong to the first subdivision, since they occupy the same limits as the entire group. Of the thirty species of pteropus, one of the most remarkable as well as the largest known species, is *Pteropus edulis* (edible roussette or kalong), which is limited to the islands of Java, Sumatra, and Bands. These bats are generally seen in great companies, consisting of hundreds or even thousands at a time; and this is also the case with other large species, as *Pteropus phaeops* and *Pteropus funereus*. The districts inhabited by all the single species occurring in the groups of islands in the Pacific Ocean and Australia, as well as some other remarkable species, are defined on the map, from which it will be observed that the common roussette (*Pteropus vulgaris*) is limited to the very small district of the islands of Bourbon and Mauritius.

2. *Pachysoma* (stout-bodied roussettes). These bats are peculiar to the Tropical province of Asia, they do not live on trees like the pteropi, but in holes and crevices of the earth. The greater number of species occur in the islands of Java and Sumatra.

3. *Macroglossus* (great-tongued roussette), consisting of only one species, is one of the family of Chiroptera, which is distributed over almost the whole of the Indian Archipelago, from Sumatra to the Moluccas.

4. *Harpyia* (tube-nosed roussettes), and 5. *Cephalotes* are also peculiar to the Indian Archipelago.

B. INSECTIVORA (INSECTIVOROUS BATS.)

6. *Dysopes* (bull-dog bat) is an inhabitant of the tropical regions, and the warmest portions of the temperate zones both of the Old and the New World, but chiefly of the latter, where, in Brazil, 8 of the 17 species occur. Of those belonging to the Old World, the most northern is *Dysopus Castonii*, which is found in Italy and Egypt.

The following 6 genera: *Diclidurus, Noctilio, Vampyrus, Phyllostoma*, and *Glossophaga*, belong exclusively to the Tropical province of America, and of the 31 species of which they consist, 18 are found in Brazil. The most remarkable genus is the vampyre bat (*vampyrus*), which, feeding on the blood of other animals, attacks all kinds of quadrupeds, and even man. Its habitat extends from the West Indies across the Isthmus of Darien, and through almost the whole of South America, with the exception of the western part of Ecuador and Bolivia to Paraguay. It was recently discovered by Mr Darwin, near Coquimbo in Chile.

12. *Megaderma* (broad-winged bats); and, 13. *Rhinolophus* (horse-shoe bats). These belong to the Old World, and 2 of the latter are found in Great Britain. *Rhinolophus unihastatus*: s. *ferrum equinum* (greater horse-shoe bat), and *Rhinolophus bihastatus*: s. *hipposideros* (little horse-shoe bat). Of this genus, 13 species are known to belong to the Indian Archipelago.

Of the remaining genera, the most common in the East Indies is

21. *Nyctiecjus* (roquet-dog bat), which is found in great multitudes, from the sea-shores to the interior of almost all the islands.

22. *Vespertilio* (proper bats). This is the most numerous genus, and inhabits nearly all the countries of the globe, 23 species belong to the European fauna alone, and of these 13 are found in Great Britain, namely:—

Vespertilio noctula (Noctula Bat).	*Vespertilio mystacinus* (Whiskered Bat).
Vespertilio Leisleri (Leisler's Bat).	*Vespertilio emarginatus* (Notched-ear Bat).
Vespertilio discolor (Parti-coloured Bat).	*Vespertilio pipistrellus* (Pipistrella or Common Bat).
Vespertilio serotinus (Serotine Bat).	*Vespertilio barbastellus* (Barbastelle Bat).
Vespertilio auritus (Long-eared Bat).	*Vespertilio Bechsteinii* (Bechstein's Bat.)
Vespertilio Nattereri (Natterer's Bat).	*Vespertilio murinus* (Mouse-eared Bat).
Vespertilio Daubentonii (Daubenton's Bat).	

The common bat is widely spread over all the northern parts of Europe, but is very rare in the south; it is probably also an inhabitant of Asia, at least some species have been brought from Japan.

DIVISION AND INTENSITY OF THE GENERA AND SPECIES.

It has already been observed, that the Carnivora increase in a direction from the polar to the equatorial regions, and that the maximum number of their species is found in the countries within the torrid zone, with the remarkable exception of New Guinea and the adjacent islands, forming the Oceanic province. In the following table we have endeavoured to present a complete view of the families and genera of the Land-Carnivora, showing the number of their species in each of the fourteen zoological provinces.

TABLE SHOWING THE DIVISION OF THE *LAND-CARNIVORA* IN THE ZOOLOGICAL PROVINCES.

FAMILIES and GENERA of the LAND-CARNIVORA, with the Number of their Species.	Zoological Provinces.													
	Australian Provinces.			Tropical Provinces.			Temperate Provinces.					Arctic Provinces.		
	Australia. 1	Oceanic Province. 2	South America. 3	Tropical America. 4	Tropical Africa. 5	Tropical Asia. 6	Central Asia. 7	Transition Province. 8	Southern Europe. 9	Central Europe. 10	North America. 11	Arctic America. 12	Arctic Europe. 13	Arctic Asia. 14
	Number of the Species.													
I. CHIROPTERA, 219	2	25	1	55	41	67	12	7	22	20	10	1	7	6
A. Frugivora (Fruitivorous Bats.)														
1. Pteropus (Roussette Bats), 30	1	13	.	.	10	12	2	.	.	.	.	.	.	.
2. Pachysoma (Stout-bodied Roussettes), 6	.	.	.	.	.	* 6	.	.	.	.	.	.	.	.
3. Macroglossus (Great-tongued Roussettes), 1	.	1	.	.	.	1	.	.	.	.	.	.	.	.
4. Harpyia (Tube-nosed Roussettes), 1	.	1	.	.	.	1	.	.	.	.	.	.	.	.
5. Cephalotes (Cephalotes), 1	.	1	.	.	.	1	.	.	.	.	.	.	.	.
B. Insectivora (Insectivorous Bats.)														
6. Dysopes (Bull-dog Bats), 17	1	.	.	10	2	4	.	.	1	.	.	.	.	.
7. Dicliderus (Fox-tailed Bats), 1	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
8. Noctilio (Hare-lipped Bats), 2	.	.	.	* 2	.	.	.	.	.	.	.	.	.	.
9. Vampyrus (Vampyre Bats), 1	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
10. Phyllostoma (Javelin Bats), 13	.	.	.	* 13	.	.	.	.	.	.	.	.	.	.
11. Glossophaga (Long-tongued Bats), 4	.	.	.	* 4	.	.	.	.	.	.	.	.	.	.
12. Megaderma (Broad-winged Bats), 3	.	1	.	.	1	2	.	.	.	.	.	.	.	.
13. Rhinolophus (Horse-shoe Bats), 20	.	5	.	.	3	12	2	3	4	2	.	.	.	.
14. Nyctophilus (South-Sea Bats), 1	.	* 1	.	.	.	.	.	.	.	.	.	.	.	1
15. Nycteris (Cheek-pouched Bats), 6	.	.	.	.	5	1	.	.	.	.	.	.	.	.
16. Desmodus (Cursed-tooth Bats), 3	.	.	.	* 3	.	.	.	.	.	.	.	.	.	.
17. Rhinopoma (Lid-nose Bats), 1	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
18. Taphozous (Wing-pouched Bats), 9	.	.	.	1	4	3	.	.	.	.	1	.	.	.
19. Mormoops (Mormoops Bats), 1	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
20. Emballonura (Long-nosed Bats), 5	.	.	.	4	.	1	.	.	.	.	.	.	.	.
21. Nyctiejus (Roquet-dog Bats), 11	.	1	.	2	2	4	.	.	.	.	3	1	.	.
22. Vespertilio (Bats proper), 81	1	1	1	12	12	19	8	4	17	18	6	.	7	6
23. Furia (Fury Bats), 1	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
II. DERMOPTERA, 3	.	.	.	.	.	* 3	.	.	.	.	.	.	.	.
24. Galeopithecus (Vaulting or Flying Cats), 3	.	.	.	.	.	* 3	.	.	.	.	.	.	.	.
III. INSECTIVORA, 61	.	.	.	4	25	15	11	4	6	10	8	7	3	6
25. Erinaceus (Hedgehogs), 5	.	.	.	1	2	1	1	1	1	2	.	.	1	.
26. Sorex (Shrews), 20	.	.	.	2	10	8	9	2	2	5	2	2	1	5
27. Hylogale (Banxrings), 4	.	.	.	.	.	* 4	.	.	.	.	.	.	.	.
28. Hylomys (Hylomys), 1	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
29. Gymnura (Oriental Hedgehog), 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
30. Myzdo (Desmans), 2	.	.	.	.	.	.	1	1	2	.	.	.	.	.
31. Scalops (Scalopes), 1	.	.	.	.	.	.	.	.	.	.	1	1	.	.
32. Macroscelides (Cape-Elephant Shrews), 5	.	.	.	.	* 5	.	.	.	.	.	.	.	.	.
33. Chrysochloris (Chrysochloris), 4	.	.	.	1	3	.	.	.	.	.	.	.	.	.
34. Centetes (Tenrecs), 4	.	.	.	.	* 4	.	.	.	.	.	.	.	.	.
35. Talpa (Moles), 8	.	.	.	.	1	.	1	.	2	1	2	.	1	1
36. Condylura (Condylures or star-nosed Moles) 4	.	.	.	.	.	.	.	.	.	.	3	4	.	.
IV. PLANTIGRADA, 34	.	.	.	12	2	11	7	4	2	3	3	3	4	3
37. Ursus (Bears), 12	.	.	.	1	1	5	6	3	1	2	2	2	3	3
38. Procyon (Racoons), 2	.	.	.	2	.	.	.	.	.	.	1	.	.	.
39. Ailurus (Pandas), 1	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
40. Nasua (Coatis), 6	.	.	.	5	.	.	.	.	.	.	1	.	.	.
41. Arctitis (Benturongs), 4	.	.	.	.	.	4	1	.	.	.	.	.	.	.
42. Cercoleptes (Kinkajous or Potos), 2	.	.	.	* 2	.	.	.	.	.	.	.	.	.	.
43. Meles (Badgers), 2	.	.	.	.	.	.	.	1	1	1	.	1	.	1
44. Gulo (Gluttons), 5	.	.	.	2	1	1	.	.	.	.	1	2	1	1
V. DIGITIGRADA, 195	1	2	12	38	62	68	25	25	12	13	27	23	17	19
45. Mustela (Martens), 28	.	.	.	2	6	7	6	5	4	6	4	8	6	5
46. Mydaus (Teledus, Telagous or Stinkards), 2	.	.	.	.	.	* 2	.	.	.	.	.	.	.	.
47. Mephitis (Skunks), 13	.	.	6	11	1	.	.	.	.	.	5	2	.	.
48. Lutra (Otters), 17	.	.	3	5	3	5	3	1	.	2	5	4	2	2
49. Canis (Dogs), 41	1	1	3	8	11	8	5	4	4	3	10	7	5	6
50. Viverra (Civets), 15	.	.	.	.	11	8	.	2	1	.	.	.	.	.
51. Cryptoprocta (Cryptoprocts), 1	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
52. Paramophilus (Paramophiles), 1	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
53. Linsang (Linsangs or Delundungs), 1	.	.	.	.	.	* 1	.	.	.	.	.	.	.	.
54. Paradoxurus (Paradoxures), 4	.	.	.	.	.	4	.	.	.	.	.	.	.	.
55. Herpestes (Ichneumons), 10	.	.	.	.	5	5	.	2	.	.	.	.	.	.
56. Ryzaena (Suricates), 2	.	.	.	.	* 2	.	.	.	.	.	.	.	.	.
57. Proteles (Proteles), 1	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
58. Cynictis (Cynictis), 1	.	.	.	.	* 1	.	.	.	.	.	.	.	.	.
59. Bassaris (Bassaris), 1	.	.	.	* 1	.	.	.	.	.	.	.	.	.	.
60. Hyæna (Hyænas), 4	.	.	.	.	4	.	1	1	.	.	.	.	.	.
61. Felis (Cats), 51	.	.	2	11	16	17	10	10	3	2	3	2	4	6
AMOUNT OF THE SPECIES OF ALL LAND-CARNIVORA, 513	4	27	13	109	130	166	55	40	42	46	50	36	31	36

Wherever this mark * occurs, the animal referred to belongs exclusively to the province indicated.

The same information which is contained in the foregoing table is given in the small tablets placed upon each zoological province in the map; but the latter present only a view of the Carnivora belonging to each separate province, whilst the above table shows at once over which province any given family or genera is distributed. This table contains a complete key for the use of those who take an interest in such inquiries—affording the means of instituting the greatest number of comparisons as to the proportions in which the entire number of Carnivora are distributed in the different provinces, the proportions which the single families and genera bear to each other in the zoological kingdoms or provinces of the same zone, &c. It may, therefore, be regarded as directing attention to some of the most important data requisite for the further elucidation of zoological geography. The figures at the foot of the table show the total number of carnivorous animals in each province; since, however, the provinces are there arranged in succession, according to zones, we have prepared the following scale, which is so arranged as to show the proportions, in an ascending order, from that province which contains the smallest to that which contains the greatest number of species, or from Australia to Tropical Asia.

Australian Provinces,	1. Australia,	4 species.
	3. South America,	13 „
	2. Oceanic Province,	27 „
Arctic Provinces,	13. Arctic Europe,	31 „
	14. Arctic Asia,	36 „
	12. Arctic America,	36 „
Temperate Provinces,	8. Transition Province,	40 „
	9. Southern Europe,	42 „
	10. Central Europe,	46 „
	11. North America,	50 „
	7. Central Asia,	55 „
Tropical Provinces,	4. Tropical America,	109 „
	5. Tropical Africa,	130 „
	6. Tropical Asia,	166 „

From this scale we see that the provinces of the same zone, in different parts of the earth, resemble each other in the number of species which they contain, but that the Tropical provinces are so completely distinguished from the adjoining Temperate provinces, that in all cases the former contain nearly *three times* as many species as the latter. For example, Tropical Asia contains 166 species, while the adjoining Temperate provinces, Central Asia, contains only 55 species, or about a third part of the number. The same proportion is observed between the two remaining Tropical provinces and the Temperate provinces by which they are limited; but the most remarkable difference is that which is observed between the Asiatic Tropical province and the two Austral provinces which border upon it, since Tropical Asia contains *thirteen* times more Carnivora than the Oceanic province, and *forty-one and-a-half* times more than Australia. In regard to the five separate families, we find that two of them are distributed over all the provinces, namely, those of the *Chiroptera* and the *Digitigrada*; that the families of *Insectivora* and *Plantigrada* are, with the exception of the three Austral provinces, also spread over all the provinces; and that only the smallest of all the families, namely, that of the *Dermoptera*, consisting of one genus and five species, is limited to a single province.

I. FAMILY CHIROPTERA.

On consulting the following scale, which shows the division of the Chiroptera in the provinces, and which is constructed on the same principle as the former, it is especially worthy of remark that the Oceanic province possesses, with the exception of the three Tropical provinces, the greatest number of species, and that besides the two species of the family of Digitigrada, these are the only Carnivora found in this province. The greater number of these occur on the islands which form the transition to the Asiatic Tropical province; for in the small group of the Banda Islands and Amboina alone there are found sixteen species; and the remaining seven species are spread over the wide district of the Oceanic province from New Guinea to the Mariana Islands on the north, and to the Friendly Islands on the east. The Roussette bats, especially, are found in nearly as great numbers in this as in the Tropical provinces of Asia and Africa.

The most extensive genus of the Chiroptera—the common bats, the species of which form more than one-third of the entire family—has also the widest district of distribution, since, with the exception of Arctic America, it extends over all the zoological provinces. It forms the southernmost limit of the family of Chiroptera in the New World, where, on the Island of Chiloé, Mr Darwin discovered a new species of Vespertilio, during the recent voyage of the "Adventure and Beagle," which has so greatly contributed to the advancement of every branch of natural science.

SECTION II.

HUNTING DISTRICTS OF THE FUR-BEARING ANIMALS, AND THEATRE OF THE WHALE AND SEAL FISHERY[1] IN THE NORTHERN HEMISPHERE,

COMPRISING THE FOUR FOLLOWING ORDERS OF MAMMALIA:—

CARNIVORA, RODENTIA, RUMINANTIA, CETACEA.

INTRODUCTION.

The distribution of the fur-bearing animals and the Cetacea forms an appropriate appendix to the Map of the Carnivora, since, although some of the animals treated of occur in each of the above mentioned orders, yet the greater number of their species belong to the Carnivora.

The Carnivora living upon the land, as well as those inhabiting the water, are constantly pursued by man, who finds in their fur-coated skins a material fitted for the immediate purposes of necessary dress, or which may be worked into the most costly articles of luxury and fashion.

In consequence of continual hunting during the last two centuries, the most valuable families have greatly decreased in numbers, and hence the price of furs has risen in an extraordinary degree. When the Cossacks conquered Kamtchatka, at the beginning of the eighteenth century, sables were so plenty that half-a-dozen could be procured in exchange for a knife, and for a hatchet a dozen was reckoned a fair equivalent; and the Kamtchatdales even smiled at strangers who gave such useful articles in return for what appeared to them objects of no value. Their barks were covered with sable skins; and for 10 rubles worth of ironware they obtained, without the slightest trouble, skins to the value of 500 or 600 rubles.

On account of this superfluity, thirty or forty pieces were risked on a game of chance, and it was little thought of whether three or four hundred sables were lost or won. These times of superfluity have long since passed away; at present, a commandant in Kamtchatka is no longer enabled to gain 50,000 rubles a-year, as was formerly the case; and the Kamtchatdales calculated, that, at the middle of the last century, their country did not contain one-fifth of the number of sables that it did at the commencement of it.

Fur-bearing animals inhabit especially the northern portions of the earth. In those latitudes where, from the nature of the climate and soil, little or nothing is to be gained by cultivation, the widely-scattered families of man are compelled to seek the means of subsistence in the produce of the chase, or in fishing; and since the civilized inhabitants of Europe have extended to the east and west, the hunting of wild animals has come to be considered by them as an important article of trade. The people of the cold countries of Upper and Farther Asia have, from time immemorial, known and practised the chase of fur-bearing animals, by which they had to supply the wants of a pressing necessity—that of providing warm clothing for the long and severe winter season. This has always led to an immense consumpt of these animals among the Mantchourian, Mongolian, Northern Chinese, and many Turkish populations.

THE ASIATIC PROVINCE.

The regions occupied by fur-bearing animals naturally form two distinct provinces—that of the Old World, or the Asiatic, and the New World, or the American province.

The Asiatic province comprises the whole of Siberia, with Kamtchatka and the river district of the Amour, or Mantchouria. Towards the south it extends also over the districts of Middle Asia, inhabited by a Turkish population, to the Sea of Aral, and stretches towards the west, over the Uralian Mountains, on the one side to the Black Sea, and on the other to the northern part of the Scandinavian Peninsula, where the chase of these animals is conducted;—in the former, by a Turkish, and in the latter by a Finnish population, who, however, are not subjected to the same necessity in its prosecution as the different natives of Siberia.

Of the order of CARNIVORA, which in this province are specially sought on account of their fur, the first eight animals are distributed over the whole district, which extends, within the limits of forests, from the western boundaries of the province, through the whole of Siberia, Mantchouria, and Kamtchatka, to Behring Strait and the Pacific Ocean :—

Ursus arctos (the common or brown bear).
Gulo borealis (the common glutton).
Meles Taxus (the common badger).
Mustela putorius (the fitchet, foumart, or polo-cat).
Mustela vulgaris (the weasel).
Mustela erminea (the ermine).
Mustela Zibellina, the sable, which, in common with the ermine, yields the most valuable fur of all the land martens.
Lutra vulgaris (the common otter).
Lutra marina (the sea otter), the fur of which is valued still higher than that of the ermine and sable, and in which a lucrative trade is carried on with China. This otter inhabits the coasts of Behring's Island, of Kamtchatka, the Kurilian Islands, and Jesso, as well as the long series of the Fox or Aleutian Isles, and the coasts of Oonalaska, whose wealth this animal constitutes. It is also found along the whole western coast of America to latitude 27° north. To this (the north-west) coast another species, *Lutra pseudo*, appears to be limited. The skin of this is as highly valued as that of the first species.

The following three species,
Mustela lutreola (the little fish otter),
Mustela martes (the common marten), and
Mustela foina (the foaline) are only found in the western part of the province, on this side of the Uralian Mountains, from the Crimea and the Caucasus to Finland.
Mustela Sarmatica (Pallas) (the tiger marten), between the Don and the Volga to latitude 53° north, and eastwards in Middle Asia.
This district is also inhabited by
Mygale moschata (the Russian musk shrew-mouse, musk-rat or desman), northwards as far as 57°, but westwards not farther than the Uralian Mountains.
Canis vulpes (the common fox), with its varieties, *Vulpes alopex*, *Vulpes crucigera* (cross), and *Vulpes Nigra* (black fox), is, within the woodlands of the whole Asiatic province, an object of assiduous pursuit; and so also is
Canis lupus (the common wolf), and *Canis lupus lycaon* (the black wolf).
Canis corsac (the yellow fox), inhabits the districts between the Ural and the Irtish Rivers and Lake Baikal, as well as the whole of Middle Asia.
Felis lynx (the European lynx).
Felis caracarca (the deer lynx).
Felis borealis (the polar lynx), the last especially, in the western districts of the province, from the farthest north to Mount Altai and the Baikal Sea.

Of the RODENTIA there are caught or hunted :—
Sciurus striatus (the earth or striped squirrel), from the Uralian Mountains to the Sea of Okhotsk and the River Amadir.
Castor fiber (the beaver or castor), on the River Obi and its tributaries. It is seldom found beyond the Yenesei River.
Lepus variabilis borealis (the northern hare), from latitude 50° north, and from the western to the eastern limits of the province, especially on the Yenesei, the Khatanga, and in Kamtchatka.
Lepus Tolai (Gm.), (Siberian hare), especially on the banks of the Baikal Lake.
Lepus hyperboreus (Pallas), (the smaller pipe-hare), in the eastern part of the province, and in the country of the Tschuk-tschi.
Lepus Alpinus (Pallas), (the stone or hay hare).

Of the RUMINANTIA the following are taken, not for their furs or hides, but on account of their musk, which is secreted in a bladder-formed cavity in the buck :—
Moschus moschiferus, L., (the genuine musk deer), which is hunted throughout the whole of the Chinese and Russian part of the country of the Tunguses, where it is found to latitude 60° north, and west from Lake Baikal to the Altai, but only in the mountainous districts, since it prefers the rugged valleys and pine-clad forests, and does not inhabit the open hill-country.

BEYOND THE LIMIT OF FORESTS, in the northernmost parts of the province, there also occur, among the Land-Carnivora :—
Ursus maritimus (the polar bear), on all the coasts of the Arctic Sea; but he is, neither here nor in the New World, expressly an object of the chase; and
Gulo borealis (the glutton), in the extreme eastern point of the Asiatic continent.
Canis vulpes lagopus (the arctic fox) or isatis, which, however, is not limited to that region of mosses and lichens—the Tundry—but extends southwards in the forest zone to latitude 60°, and in Kamtchatka to the outermost point of the peninsula, whence it finds its way on flakes of ice to the Aleutian Isles.
And among the RUMINANTIA :—
Cervus tarandus (the rein-deer), is hunted by the Tschuk-tschis for the sake of its skin. It is only found in its wild state within the polar circle.

The following NATIVE TRIBES are occupied with the objects of the chase in the Asiatic province :—

1. The Finns, on both sides of the Uralian Mountains, who hunt the lynx, the fox, the marten' ermine, and squirrel, as well as the bear and wolf—for the capture of the last of which a premium is awarded by the Government of Norway. The European Finns follow the chase only as an occasional occupation.
2. The Turkish tribes to the south of the Uralian Mountains, and eastward to the Rivers Irtish and Altai, hunt the martens, the musk shrew-mouse, the polar lynx, and especially the corsac or yellow fox—the skins of which form so important an article of trade, that from forty to fifty thousand are annually conveyed to Orenburg alone.
3. The Samoides, on the borders of the countries occupied by the Finnish and Turkish tribes; and
4. The Yenesians, who chase the bear, the wild rein-deer, the wolf, hare, fox, the sable (which occurs but seldom on the River Obi), the striped squirrel, and occasionally the ice-fox and the glutton.
5. The Yakuts, a people of Turkish origin, who hunt the noble sable, especially at Olekminsk and at Aldan; the noble dark-brown fox near Kolima and Suschiwersk; the ermine at Wilui and Kolima; the ice-fox and musk-deer, as well as the bear.
6. The Tunguses, between the Icy Sea on the north, and the Seas of Okhotsk and Japan on the south, who, in the far north, chase the wild rein-deer, the sable, the musk-deer, the squirrel, and the fox. As the people of Siberia pay their imposts to the Russian Government in the skins of the noble species, so the Tunguses or Mantchous offer their tribute in those of the sable.
7. The Ainos, on the eastern border of Mantchouria and the Island of Tarakai (or Sagalian), who also, like their brethren in Jesso and the Kurilian Islands, appear to take part in the capture of the valuable sea otter. All traffic at the trading stations of Mantchouria is carried on by the exchange of skins for the merchandise of China.
8. The Yukagers, the Koriaks, and the Tschuk-tschis, inhabiting the north-eastern part of the Asiatic continent, as well as the Helman (or Kamtchatkans), inhabitants of the peninsula of Kamtchatka, hunt the marten, the sable, the ermine, the fish-otter, fox, ice-fox, the bear, the wolf, the glutton, wild rein-deer, and the hare.

The present traffic in furs in the Asiatic province is, if not more important than formerly, at least very considerable, and produces an enormous profit, which has this peculiarity, that the seller as well as the buyer share in it. This is brought about in the following manner: The Tschuk-tschi, for example, the most active trader of these northern regions, does not always procure his goods himself, but purchases them from his countrymen on the other side of Behring Strait; from them he receives for one-half pood[a] of leaf tobacco a parcel of skins, which he sells again to the Russians for two poods of the same. These two poods of tobacco cost the Russian at the most about 150 rubles[b]; for these he obtains a parcel of furs, which he sells again for at least 400 rubles, and so gains 250 per cent.

The trade between the Tschuk-tschi and the Russians is carried on at a great annual fair, which is held at a place called Ostwornoi, on the Aniuy river, latitude 68° north, longitude 163° 45' east. There the most valuable fur is that of the sable, which is only exceeded by the skin of the black fox. The former is sometimes sold for 40, and the latter from 58 to 100 rubles each, even at the place where they are caught.

THE NORTH AMERICAN PROVINCE.

Three natural districts—the Woodlands, the Savannahs or Prairie Lands, and the Barren Grounds of the polar regions—divide this region. The Woodlands occupy the middle space. The Savannahs extend southward through the Valley of the Mississippi-Missouri, and stretch beyond the Rocky Mountains, over the district of the Columbia River, to the Pacific Ocean. The Barren Grounds lie to the north of the forests; they are distinguished by an almost entire absence of vegetation, the rock being only at intervals covered with a thin soil, which is seldom sufficient to support a shrub or stunted tree. Each of these three districts, according to the nature of the nutriment it affords, is characterized by peculiar genera, or at least peculiar species of fur-bearing animals.

The FOREST REGION has the greatest number. In it there occur of the order of the Carnivora :—
Ursus Americanus (Pallas), (the American black bear).
Procyon lotor (the racoon).
Meles Labradorieus (Sab.), (the Labrador badger).
Mustela Martes, L. (the common or pine marten).
Mustela Canadensis, L. (the pitan or fisher marten).
Mustela erminea, L. Gm. (the ermine).
Mustela vison, L. Gm. (the vison or mink).
Mustela lutra Canadensis (the Canadian otter).
Canis vulpes fulva (American or red fox), with the variety *decussata* and *argenista*, black or silver fox.
Felis borealis v. *Canadensis* (Geoff.), (the polar lynx).
Felis rufa (the brown lynx).

Of the order of RODENTIA, which are sought on account of their furs, the following especially belong to this district :—
Castor Americanus (F. Cuv.), (the American beaver) and
Fiber zibethicus (Cuv.), (the musk rat or musquash); as well as the
Lepus Americanus (Erxl.), (the American hare).

And of the RUMINANTIA :—
Cervus alces, L. (the moose-deer), and
Cervus tarandus, L. (the rein-deer).
The following belong in common to the FOREST REGION and the REGION of the BARREN GROUNDS :—
Gulo luscus (Sab.) (the wolverine).
Canis lupus Occidentalis (Rich.), (the American wolf).

In the region of the BARREN GROUNDS are found exclusively :—
Ursus arctos (the brown or barren-ground bear).
Ursus maritimus (the polar bear), which frequents the coasts of the continent and islands of the Arctic regions.
Canis vulpes lagopus (the arctic or polar fox), on the continent as well as the islands.
Lepus glacialis, the polar hare, northward to Melville Island.

In the third, or PRAIRIE REGION, the following are abundant :—
Ursus horrœ (Lew. and Clark) (the grizzly bear), the most formidable animal of its species, and of the North American continent. It is common on the slopes of the Rocky Mountains, and is distributed also over the eastern savannahs as far as latitude 61° north; and its southern range is probably the northern borders of Mexico. The hunting of this bear is attended with great danger.
Canis lupus (v. *Ipiciaca*) *latrans* (the prairie wolf), is smaller than *Lupus Occidentalis*. This is found in great numbers in the plains of the Rivers Saskatchewan and the Missouri.
Canis vulpes cinereo-argentata (the grey fox), the smallest of the North American foxes, the fur of which is of little value.
Lepus Virginianus (Haslus),
Cervus strongyloceros, (Shreb.), *Cervus Canadensis*, Gm. (the wapiti), inhabiting the savannahs on both sides of the Rocky Mountains.

Of all these animals the beaver and the bisam-rat are of the greatest importance in the American fur trade. These two species, indeed, form the staple of this trade; for it is calculated that from eighty to ninety thousand beaver skins, and more than half a million musquash skins, are annually imported into Europe alone.

FUR-BEARING ANIMALS IN THE SOUTHERN HEMISPHERE.

There is also a hunting district for fur-bearing animals in the Southern Hemisphere; but, on account of its small extent and limited population, it has not been deemed necessary to insert it on the map. It lies in the temperate region of South America, in Chile, Tucuman, and Buenos Ayres, but chiefly in the river district of La Plata, and on the western side of the Cordilleras, in the Archipelago of Chonos, and is inhabited by *Myopotamus bonariensis* (Commerson), *Hydromys coypus* (Geoff.)—the marsh-beaver, which in Chile is called coypu, and in the pampas quuiya—the beautiful skin of which is known in the fur-trade under the Spanish name of nutria.

THEATRE OF THE CAPTURE OF THE NORTHERN WHALE AND THE SEAL TRIBE.

The voyages of the Dutch and English navigators through the Polar Seas, in search of a north-east or north-west passage, were the means of making known the habitat of the Cetacea. The companions of Barentz, who in the year 1596 discovered Spitsbergen, and the exploration of Hudson, who soon after attempted the north-west passage, drew the attention of their several countrymen to the vast number of whales which were found in those seas, and opened up an immense field for the activity of their adventurous seamen, and the speculation of their enterprising merchants. Manned by Basque seamen, who ever since the twelfth century had followed with the greatest success the hunting of whales in the higher latitudes of the Atlantic Ocean, the Dutch, the English, Hamburgers, French, and Danish, sent ships to the Greenland Seas, to prosecute a branch of industry which held out such enticing prospects of gain. The Dutch, from their greater activity and industry, soon acquired an advantage over all their competitors. In the latter part of the seventeenth century they carried this trade to the greatest perfection, and there were seasons in which not fewer than 260 ships and 14,000 seamen were employed in it; but, through insatiable avarice, this branch of industry was lost to the Basques in the beginning of the fifteenth, and to the Dutch in the eighteenth century.

The family of the Balænæ is either extirpated or so greatly reduced in numbers in the Greenland Seas, that the most experienced seaman can no longer reckon on a profitable produce. He is, therefore, compelled to seek new ground for exertion; and during the last thirty years, since the discoveries of Ross, Parry, Lyon, and others, attention has been turned especially to Baffin Bay, Hudson Bay, and other portions of the Arctic Ocean, where the trade is now chiefly in the hands of the English.

The average quantity of British shipping employed in this trade during the nine years ending in 1818 was,—

From England,	91	132
From Scotland,	41	
The number sent out in 1820 was,—		
From England,	41	91
From Scotland,	50	

Showing a decrease in the interval of 40 ships. This decrease is steadily progressing up to the present time. In the year 1820, which was peculiarly disastrous to the whole fishery, 19 British ships were totally wrecked, and 12 seriously injured during the season.

[1] We use this phrase in compliance with general custom, although it appears as anomalous to apply the term "fishing" to the capture of mammiferous animals as it would be to speak of the "hunting of fishes." The prevalence of this custom has, doubtless, tended to keep alive the vulgar notion that whales are fishes.

[a] A Russian pood is equal to 36 lbs.

[b] A ruble is equal in value to 3s. 1½d. sterling.

II. FAMILY DERMOPTERA.

This is the smallest of all the families, consisting of the genus *Galeopithecus* (vaulting or flying cat), which inhabits exclusively the Tropical province of Asia. The best known species, namely, *Galeopithecus variegatus*, was observed by Salomon Müller, on the islands of Java, Sumatra, and Borneo; and it is said also to have been observed by Diard in Siam and the Peninsula of Malay. This most remarkable animal, which is about the size of a domestic cat, is of a wild and jealous disposition; when disturbed in its rest, it emits a peculiarly disagreeable screaming and chattering cry, and bites itself with rage. Another species is found in Gugensi, and also in the Philippine Islands.

III. FAMILY INSECTIVORA.

The animals of this order, as the name implies, are appointed to keep in check the overwhelming increase of the insect world.

25. *Erinaceus* (hedgehogs). This animal belongs mostly to the Old World; the European hedgehog occurs in most of the countries of Europe; it is distributed over the cultivated parts of England, and in the southern part of the middle division of Scotland, but is not found in the northern districts of the country, nor in the Northern or Western Islands.

26. *Sorex* (shrews). Of this, the most numerous genus of the Insectivora, three species belong to Great Britain; namely, *Sorex araneus* (common shrew), *Sorex fodiens* (water shrew), and *Sorex remifer* (oared shrew).

The habitat of the remaining genera, which are mostly confined to one or two zoological provinces, is shown in the table, page 2. We may, therefore, confine our remarks to the two genera which have the widest district of distribution, and are best known. Of these

30. *Myogale* (desmans), is an inhabitant of marshy and humid soils. *Myogale Moscovitica* (Muscovite desman), is abundant in the countries to the south of the Volga, and in the vicinity of Voronetz; the other species, *Myogale Pyrenaica* (Pyrenean desman), is found near Tarbes, in France.

33. *Talpa* (moles). *Talpa Europæa* (common mole), is one of the smallest, but most numerous of the Carnivora. It inhabits chiefly the countries of Central and Northern Europe, extending southward to the Pyrenees, the north of Italy and Greece, and eastward to Siberia. It is not known in the north of Scotland, in the Orkneys, or Shetland Islands, nor in any of the Hebrides, excepting the Island of Bute. It is not found in any part of Ireland, but is common in all the other parts of Great Britain.

IV. FAMILY PLANTIGRADA.

37. *Ursus* (bears). Europe, Asia, and America, have each their peculiar species of this genus. Its existence in Africa has long been a matter of doubt, but it is now ascertained that a species of bear is found, though rarely, in Abyssinia, in the chain of Mount Atlas, and in the Tetuan Mountains. *Ursus arctos* (brown bear), was formerly common in almost every country of Europe, but at present it is very seldom met with, except in the northern districts of Norway and Russia, where within the arctic circle, it probably extends through Siberia and Kamtschatka to Japan in the east. It is occasionally, though rarely, seen in the recesses of the Alps. In the Pyrenees and Asturian Mountains, is found the variety *Ursus Pyrenæus* (Pyrenean bear). Among the Asiatic bears, the most remarkable are: *Ursus Syriacus* (Syrian bear), which is but seldom met with. *Ursus Tibetanus* (Tibet bear), an inhabitant of the mountains of Silhet and Nepaul, and *Ursus Malayanus* (sun bear of Sumatra). Of the American bears, the most ferocious is *Ursus ferox* (the grizzly bear), a native of the Rocky Mountains, and the district to the eastward. It has been observed as far north as latitude 61°; and southwards, it is said to extend to the borders of Mexico. *Ursus Americanus* (the American black bear) inhabits all the wooded districts of the American continent, from the Atlantic to the Pacific Ocean, and from Carolina to the shores of the Arctic Ocean. *Ursus maritimus* (the polar bear, or white bear of the Icy Sea) inhabits all the northern regions of the globe on the shores of the Arctic Ocean, extending southwards, at farthest, to about latitude 65° north. It has been observed in Norway, Iceland, Greenland, and as far west as Barrow Strait.

38. *Procyon* (racoons). Notwithstanding Buffon's assertion to the contrary, the racoon inhabits Canada, as well as the warmer regions of America, its range being from about 50° north latitude, through Mexico, and the United States, and South America to Paraguay.

42. *Meles* (badgers). The badger is distributed over all the countries of Europe and North-West Asia. It is the only species belonging to the family of the Plantigrada which now occurs in Britain, where, however, it is nowhere abundant, and in many districts is extremely rare.

44. *Gulo* (gluttons). The European glutton, the district of which is defined on the map, is most common in Norway, Northern Russia, and Siberia. In equally high latitudes in North America, there is found *Gulo luscus* (wolverine), and in South America, *Gulo vittatus* (grison).

V. FAMILY DIGITIGRADA.

This family comprehends the most sanguinary, and consequently the most typical of the Carnivora. The following are among the most remarkable and numerous of the species:—

45. *Mustela* (martens). Except the three Austral, these are distributed over all the zoological provinces. Of the 28 species, 7 belong to Europe, and of these 4 are found in Great Britain, namely, *Mustela putorius* (fitchet, pole-cat, or foumart); *Mustela erminea* (stoat or ermine); *Mustela vulgaris* (weasel); and *Mustela foina* (foine or beech marten). Of these 4 species, it appears that in England generally, the ermine is less common than the weasel; but in Scotland, even to the south of the Firth of Forth, the ermine occurs most frequently. The marten is common in England and Scotland. It is spread over the whole of Europe, especially in the northern districts. A detailed account of the distribution of these animals in the northern regions of Asia and America will be found in the description of the fur-bearing animals in the second section of this sheet.

46. *Mydaus* (teledus). This animal which, in the Old World, occupies the place of the skunks, in America is confined to the islands of Java and Sumatra.

47. *Mephitis* (skunks) inhabit North and South America, from Canada to Chile.

48. *Lutra* (otters). *Lutra vulgaris* (common otter) is found generally in all the lakes and rivers of Europe, as well as on the coast. It is common on the shores of Scotland and Ireland, and on the rocky shores of the Hebrides and Shetland Islands.

49. *Canis* (dogs). This genus, the most useful to man in all conditions and in all climates, is spread over the whole globe, yet it (that is the wild dog, for domestic animals are not here spoken of) follows the general law of distribution, and increases in number from the polar to the equatorial regions. But, although the Tropical provinces of Asia contains, next to Africa, the greatest number of species, there appears to be a total absence of the dog tribe in India beyond the Ganges. And in the Indian Archipelago, generally so rich in Carnivora, only two species are known. In Australia and the Oceanic province, the genus Canis is represented by *Canis Nova Hollandiæ* (dingo) which is spread over Australia, New Guinea, and New Britain. *Canis lupus* and *Canis vulpes* have the widest district of any of the dog tribe. *Canis lupus*, (wolf) the typical wolf of Europe and Asia, and the varieties belonging to this tribe in America, may be said to occupy both continents from the arctic circle on the north, to Spain and probably even to Morocco on the west; to Egypt, through Syria to beyond the Crishna in India on the east of the old continent; and to near the Isthmus of Panama in America. *Canis lupus vulgaris* (the common wolf). During the last century, this animal has been driven from the plains of Central Europe to the recesses of the Pyrenees and the Carpathian Mountains; but it is still found in Poland, some parts of Austria, France, Italy, and Spain; and is still common in Norway, Sweden, and Russia. *Canis vulpes vulgaris* (the common fox) is distributed over the greater part of Europe and Northern Asia, and is the only representative species of this genus in Great Britain. *Canis aureus* (jackal). This, which is the characteristic dog of Africa, has a district extending from the Senegal to India, and from Abyssinia and Caffraria to European Turkey and Southern Russia.

50. *Viverra* (civets). Of this genus, *Viverra genetta* (the genet) is found in the northern districts of Africa, in the south of France, and in the countries bordering on the Mediterranean; where, in Turkey, it is tamed and domesticated.

60. *Hyæna* (hyænas). The hyænas generally belong to the southern countries of Africa, but one species—*Hyæna striata v. vulgaris* (striped hyæna)—extends to Asia. It is spread over the countries from Soudan, Senegambia, and Abyssinia, over Barbary, Arabia, Nubia, Egypt, Syria, Asiatic Turkey, Persia, and India, northward to Caucasus and Altaic Mountains.

61. *Felis* (cats). This genus, comprising the most powerful and ferocious of all predatory animals—including the lion, the king of beasts—is distributed over the whole globe. With the exception of the Oceanic province and Australia, the Islands of Japan, and probably the Philippine Isles, it is found in all the zones, extending to the limits of forests in the frigid zone. The species inhabiting America differ greatly in appearance from those of the Old World, and so in general smaller in size. None have yet been found on the western declivity of the Andes of Bolivia and Peru. *Felis leo* (lion) is spread over almost all the countries of Africa—from the Cape Colony to Barbary—except in the countries of the Nile, including Egypt from the Abyssinian plateau northward, and Darfur, Kordofan, and the Lybian Desert, where at present no lion is to be found. In Asia the lion is confined to a much smaller region, for its district extends only from Mount Zerdà Kob, in the Persian plateau (latitude 32 north), to Gugerat, and the jungle countries of India and the districts bordering on the Euphrates. *Felis discolor v. concolor* (puma or cagnar) is the lion of the New World; it has a very extensive range over both continents of America. Towards the south it extends to Patagonia, in latitude 53° to 54° south; and in the north it extends on the one side to California, and on the other to Pennsylvania and the Canadian Lakes, in latitude 49° or 50° north. Nearly equal to the lion in strength, and perhaps excelling him in activity, *Felis tigris* (the royal tiger) is confined to the countries of Asia. Although the larger species of the cat tribe are limited in general to tropical countries, yet the royal tiger, which has its chief habitat in the jungles of Bengal and the islands of Java and Sumatra, occasionally extends as far as the Altaic Mountains, whence it frequently makes incursions into Siberia, and beyond the Lake of Baikal. It is distributed over the countries, from Mount Zerdà Kob, in Persia, eastwards to Corea, Siam, and Tonquin; and it is said to occur also in the south of China. The corresponding cat of the New World is *Felis onça* (the jaguar or American tiger), the principal habitat of which is Brazil and Paraguay. It extends southwards to the Rio Negro, and to Lake Nahuel-Huassi (latitude 42° south), which derives its name from the Indian designation of the tiger. On the north it is not quite ascertained whether it extends to the borders of Mexico. Of the European cats, *Felis catus* (wild cat) is the only representative in Great Britain. It is spread over the greater part of Europe, Germany, Hungary, Russia, and occurs also in Asia Minor. It is not found in the South of England, and but rarely appears in the wooded mountainous districts of Cumberland and Westmorland; but in the wild districts of the north of Scotland and in Ireland it is still abundant.

DISTRIBUTION OF THE CARNIVORA IN A PERPENDICULAR DIRECTION.

As intimated in the notes accompanying the first Map of Zoological Geography, we have endeavoured graphically to represent the distribution of Carnivora in mountainous regions; and although the observations on this subject are very deficient, we have been enabled to construct an interesting diagram, showing the elevation at which the different animals are found above the level of the sea, in the torrid and temperate zones. This diagram is constructed on the same scale as that on the Map of Botanical Geography (No. 1), and a similar method of representation is here employed; that is to say, that figures of the animals, drawn according to form and magnitude, in so far as the limited space would permit, are placed on the diagram at the height of their occurrence; and further, each of these is accompanied by a number, referring to its name, at the foot of the design. The diagram represents four different regions or provinces, of which three belong to the Old and one to the New World.

I.—TEMPERATE ZONE OF EUROPE.

The darkest group, forming, as it were, the foreground of the picture, exhibits the Alps, and, as represented by them, the temperate zone. Here, in the Valley of Urseren, which lies in the centre of the Alpine range (in the Swiss Canton of Uri), which, from its lowest point of 4,640 feet, rises at the Hospice of St Gothard, to a height of 7,100 feet, Schinz observed the various carnivorous animals at the elevations mentioned under his name in the following table. The others were observed by Fitzinger in the Alps of the Archduchy of Austria, to a height of from 2,900 to 8,250 feet.

I. CHIROPTERA.

	Schinz.	Fitzinger.
Rhinolophus ferrum equinum minor (Smaller Horse-Shoe Bat),		from 4500 to 8250 feet.
Vespertilio noctula (Noctule Bat),	4500	8250
Vespertilio serotinus (Serotine Bat),	4500	8250
Vespertilio murinus (Mouse-eared Bat),	2900	4500
Vespertilio (Bats proper),	7030	

III. INSECTIVORA.

Erinaceus Europæus (European Hedgehog),		from 4500 to 8250 feet.
Sorex fodiens (Water Shrew),	2900	4500
Sorex araneus (Continental Shrew),	2900	4500
Sorex (Shrews),	7030	
Talpa (Moles),	7030	

IV. PLANTIGRADA.

Ursus arctos (Brown Bear),		from 4500 to 8250 feet.
Ursus niger (Black Bear),	4500	8250
Ursus Pyrenæus (Pyrenean Bear),	8000	
Meles vulgaris (Common Badger),	6400	2900 4500

V. DIGITIGRADA.

Mustela putorius (Fitchet or Foumart),	5500	from 2900 to 4500 feet.
Mustela vulgaris (Weasel),	5500	2900 4500 "
Mustela erminea (Stoat or Ermine),	8000	4500 8250
Mustela martes (Common Marten),		4500 8250
Mustela Foina (Foaine),	5500	4500 8250
Lutra vulgaris (Common Otter),		4500 8250
Canis lupus vulgaris (Common Wolf),		4500 8250
Canis vulpes vulgaris (Common Fox),		4500 8250
Felis catus (Wild Cat),		4500 8250
Felis lynx (European Lynx),		4500 8250

These are all the observations on record for the region of the Alps; and from these it appears that Mustela erminea (the ermine), is found at the greatest elevation, preferring as its residence the region of the Alpine shrubs. Its habitat, as shown on the map, is beyond the lower limit of perpetual snow. The bear, not only in the Alps, but also in the Pyrenees, occupies the highest desert regions towards the snow line, chiefly at a height of 7,700 feet above the level of the sea. The lynx ascends the Pyrenees to the same height as in the Alps, namely, to 8,000 feet. In Northern Europe, Gulo borealis (the glutton) ascends the highest of the Scandinavian Alps, the forests of which are also inhabited by Canis lupus (the common wolf); but the latter frequently makes incursions into the plains, especially in winter, when the mountains are covered with snow.

II.—TORRID ZONE.

(a) ZOOLOGICAL PROVINCE OF TROPICAL ASIA.

This division is represented by the lightest group in the background, and is surmounted by the Peak of Dhawalagiri. Salomon Müller, the indefatigable naturalist of the Indian Archipelago, is almost the only authority on whom we can rely for facts concerning the perpendicular distribution of the Carnivora in Tropical Asia. Of the

I. FAMILY CHIROPTERA, the genus *pteropus* inhabits chiefly the level districts of the country; hence it is often found in cultivated places, and even in the midst of the villages. Yet it is sometimes met with at a height of 4,200 feet. *Pachysoma* (stout-bodied Rousettes). These animals inhabit chiefly the hollows of the higher lying districts and mountain forests; and *Pachysoma hitherkeitelum* is found at the height of 6,400 feet. Of the *Rhinolophus* (horse-shoe bat) some species ascend to the height of 9,000 feet. Among the

V. FAMILY DIGITIGRADA, *Mustela Hardwickii* occupies a height of 8,000 feet. *Mydaus meliceps* (telagon or stinkard) is a true mountaineer, and in the great forests of the Sunda Islands travels to a height of 6,400 feet. *Lutra leptonyx* lives in the Island of Java, as well in the sluggish rivers of the plains as in the wild mountain torrents of the higher districts, where, in the rocky wooded hollows, it is found at a height of 2,600 feet. *Lissong graecile* is found at a height of 1,800 feet. *Felis tigris* (the royal tiger) is found in the Islands of Java and Sumatra, from the sea-shore to a height of at least 5,800 feet, although never deep in the interior of forests, but generally on promontories and in thinly inhabited tracts, covered with low underwood, or where extensive fields of Alang-alang (Imperata Koenigii) and other luxuriant plants of a shrub and tree-like form (Saccharum glaga, Eletheria coccinea pinings, &c.) cover the soil. On the continent of India, the tiger, as well as the leopard, travels in search of prey from the foot of the Himalayan Mountains to the upper regions, at an absolute elevation of 9,600 feet, where vegetation loses its tropical character, and assumes that of the temperate zone, where the wood consists almost entirely of rhododendron arboreum, quercus, acer, ulmus, and carpinus. The tiger, as well as the leopard and panther, frequents the naked woodless table-lands of Tibet, where, in the clefts of the mountains, it attains a height at least equivalent to that of Mont Blanc. On comparing the principal habitats of the tiger in the plains of Bengal with its occurrence in the valleys of Dunries and beyond Lake Baikal, it appears that it lives in isotherm latitudes which range between the mean annual temperature of 81° and the freezing point (32°).

(b) ZOOLOGICAL PROVINCE OF TROPICAL AFRICA.

The small mountain on the right hand side of the diagram, containing only the figures of two animals, represents Africa. These two individuals belong to the

V. FAMILY DIGITIGRADA. The one is the *black-maned lion* of the Cape Colony, which is chiefly found in the open plains of the table-land. These plains stretch from the foot of the Wit and Winter Mountains, in the north-eastern districts of the Cape Colony, at an average height of 4,800 feet above the level of the sea. At the same elevation the *Hyæna venatica*, in great herds, not only pursues the peaceful antelope, but attacks the lion and the panther, which, notwithstanding their great strength, are overpowered by numbers, and fall in general an easy prey.

(c) ZOOLOGICAL PROVINCE OF TROPICAL AMERICA.

This province is represented on the left hand side of the diagram, crowned by Chimborazo, as representative of the chain of the Andes. It contains but few animals. Of these three belongs to the

IV. FAMILY PLANTIGRADA, only the bear. This animal, according to Humboldt's picture of the Andes, attains a height of 16,000 feet, which is immediately on the confines of the snow line. The others belong to the

V. FAMILY DIGITIGRADA, among which *Mephitis mesaritis* ascends to a height of 8,000 feet. Of the genus *Felis*, *Felis discolor* (puma) ascends the Cordilleras of Chile to a height of at least 11,000 feet, an elevation which, in that latitude, cannot be much under the limits of snow. In the Andes of Peru, *Felis onça* (the jaguar) scarcely attains a height of 3,000 feet; whilst, in the same region, *Felis pardalis* (the ocelot) ascends to twice that height above the level of the sea, penetrating beyond the region of palms and pining plants to the uppermost limits of chinconas and tree-ferns.

The *Cetacea* (whales), forming the last order of Mammalia, are divided into two great tribes, the *ordinary* and the *Herbivorous Cetacea*. The first and most important group, which range throughout the depths of ocean, and feed upon the usual prey of fishes, consist of the two families—*Balænidæ* (true whales, rorquals and blubber whales), and *Physeteridæ* (cachalots or spermaceti whales). The second group consists of the third family *Delphinidæ* (narwhals, dolphins, grampuses, porpoises), &c. These, although entirely aquatic, frequent generally the estuaries of rivers, and feed on the vegetable substances which grow on the shores.

Those of the Cetacea which form the immediate subject of inquiry, the habitat of which is chiefly in the seas of the Northern Hemisphere, are the following :—

I. FAMILY BALÆNIDAE.

Balæna mysticetus (common, Greenland or right whale). In a commercial point of view, this is the most important of all the Cetacea, since it furnishes more oil than any of the others, while, from the slowness of its movement, and its timidity, it affords greater facilities of capture. From the earliest records of whaling, we find that *Balæna mysticetus* were captured in the Atlantic Ocean, as far south as the line marked on the map—" occasional extension of whales ;" and at the beginning of the present century, they were found in great numbers at the entrance to Hudson Strait, and on the borders of the ice, near the coast of Labrador. In the year 1817 the whalers proceeded northwards to Lancaster Sound, and occasionally entered Barrow Strait ; but this, which was called the south-west fishery, has, in its turn, been abandoned, since, in the language of whalers, it is " fished out." Whales have thus been found gradually to retire more and more to the northward ; and they are now found in considerable numbers only to the north of Lancaster Sound. They are still captured, however, in Hudson Bay and Davis Strait ; but they are seldom seen in the Greenland Sea, or in the vicinity of Spitzbergen, where they were formerly so numerous.

Balænoptera boops v. *Rorqualus borealis* (great northern rorqual) is found chiefly along the edge of the ice between Bear or Cherry Island and Novaia Zemlia, as well as in the vicinity of Jan Mayen Island, and towards Spitzbergen, between the parallels of 70° and 76° ; it also occurs at the mouth of the Firth of Forth, and when the sea is open, in the summer months, it advances to the northward as far as the 80th parallel.

Balænoptera acuto-rostrata v. *Rorqualus minor* (lesser rorqual) frequents the rocky bays of Greenland, especially during the summer months. It is also found on the coasts of Iceland and Norway, and sometimes even in lower latitudes—a specimen having been caught near Queensferry, in the Firth of Forth, in 1834. On the Norwegian coasts, from Finnmark down to the lower latitudes of Bergen, a species of whale, *Balæna glacialis* is occasionally caught. This is sometimes considered as a separate species, sometimes as a young mystiocete ; but Oken is disposed to consider it rather as a young rorqual. It follows the herring to the innermost recesses of the Scandinavian fiords ; as soon as it has entered sufficiently far, the mouth is closed with a strong net, he is then fired at with arrows, and allowed to swim about for five or six days till he dies. The Firth of Forth, on the east coast of Scotland, is remarkable for the number of whales which occasionally visit it.

The Pacific Ocean is also inhabited by a great number of whales, which frequent the coasts of the Russo-American colonies, and the inhabitants of Kodiak and Oonalashka have for many years engaged in its capture. But it is only since 1833 that the Russo-American Company have begun to avail themselves of the European method of capturing the whale, by the use of the harpoon. The inhabitants of the Aleutian Islands distinguish four species of *Balænæ*.

II. FAMILY PHYSETERIDAE.

Physeter macrocephalus (spermaceti whale.) The sperm whale, being a gregarious animal, is found in herds occasionally consisting of two, four, or even six hundred together. It chiefly inhabits the southern seas; yet it is found in Baffin Bay and Davis Strait, whence it sometimes makes excursions into the Atlantic Ocean, where it is even followed by American fishers from the bank of Newfoundland and the Azores. It appears also in the Pacific Ocean, oftener at the Aleutian Isles than at Kodiak. In the Firth of Forth, *Physeter macrocephalus* (spermaceti whale), as well as *Physeter tursio* (high-finned cachalot) occasionally occur.

III. FAMILY DELPHINIDAE.

The most remarkable among this family is *Narwhalus* v. *Monodon monoceros* (narwhal or sea unicorn). This is regarded by the inhabitants of Greenland as a migrating animal. Its favourite resort appears to be among the ice fields of the polar regions, and the bays and creeks of the Greenland coast ; especially in Disco Bay, Davis Strait, and the shores of Iceland. In these latitudes it is sometimes very abundant ; while it is occasionally found wandering, as if out of its element, near the shores of Northern Europe and the British Isles. It is seldom or never found in southern latitudes. Its home seems to be between 70° and 80° of north latitude.

Delphinapterus leucas (beluga or white whale). The chief habitat of this species is in the higher latitudes of the arctic regions. It is abundant in Hudson Bay, Davis Strait, and in some localities on the northern coasts of Asia and America, where it frequents the principal rivers. Steller mentions this species as occurring at Kamtchatka ; and, according to Charlevoix, it is abundant in the Gulf of St Lawrence, where it follows the tide as far as Quebec. It also abounds near Disco Island, in Greenland, and is frequently found near Spitzbergen ; but Mr Scoresby never observed it further to the south than the latitude of Jan Mayen Island ; it is also found, however, in the Firth of Forth.

Delphinus globiceps (deductor or cuing whale). The chief habitat of this species is between latitude 56° and 60° north ; but it is often found in lower latitudes ; and in 1832, 98 were captured on the shores of Lewis, one of the Hebrides or Western Islands. It also occurs at the Orkney and Shetland Islands.

Delphinus phocæna (common porpoise). The porpoise occurs in all the seas of Europe ; but is most abundant on the western shores of Ireland, which it frequents in innumerable shoals.

Delphinus grampus (the common grampus) is found on the coasts of Greenland, Spitzbergen, and Davis Strait. It also frequently appears in small herds in the seas and firths of the British islands, probably in all seasons of the year.

SEAL FISHERY.

The most important seal fishery at present is that which is prosecuted in the seas between Greenland and America by the adventurous seamen of Newfoundland and Nova Scotia, who, early in spring, in the months of March and April, approach the ice-fields, which are floated by the currents from the polar regions, and on which great herds of seals have embarked on a voyage to warmer climates. These fields of ice are called in America sea-meadows. On these, and along the coasts of Labrador, &c., the fishermen of Newfoundland and Nova Scotia annually slaughter more than half a million seals. If to these we add the number caught by the English and Dutch, on the coasts of Greenland and Spitzbergen; by the Russians and Scandinavians on their own coasts ; the Russians in Behring Strait, the Sea of Okhotsk, the Caspian, the Aral, and the Balkan, &c. ; we may calculate the entire number of seals annually captured at least at one million.

The seals and morses, as already noticed, form the sixth family of the *Carnivora*, that of *Pinnipedia*. The following are the most important seals belonging to the Northern Hemisphere :—

Phoca vitulina (the common seal) is distributed over all the northern districts, on both sides of the Atlantic Ocean, from the Baltic and North Sea to the Icy Ocean.

Phoca fœtida, is found also in the northern seas of both hemispheres, from the Baltic to the Arctic Ocean.

Phoca Groenlandica (the harp or Greenland seal), the most prevalent species in the Arctic Seas of the New World, is found in winter on the eastern shores as far as latitude 43° north ; it occurs also at Kamtchatka, and on Iceland, but is rarely found on the east side of Greenland, or at Spitzbergen.

Phoca barbata (the bearded or great seal), is found in Spitzbergen, and in the whole sealing district of the New World. On the coasts of Kamtchatka, it occurs from latitude 56° to 64° north.

Phoca leucopla is most prevalent on the coasts of Iceland.

Phoca ingrava is found almost exclusively on the coasts of Newfoundland.

Phoca hispida (the rough or bristled seal) is an inhabitant of the Baltic Sea and the coast of Norway, where it is regularly hunted ; it is also found in great numbers in the northern seas of the New World, in Davis Strait, and its vicinity. According to Giesecké, many thousands of this species are killed every year on the west coast of Greenland, about latitude 72° north.

Phoca cristata (the crested seal) appears to inhabit chiefly that part of the Arctic Ocean in the region of Greenland, where it is mostly found in the open sea, and approaches the coast only in the months of April, May, and June. It is abundant in Davis Strait, and on the northern shores of America.

Phoca oceanica (the ocean seal) prefers the colder regions of the ocean, and hence it is only found along the borders of the ice in the White Sea ; but, according to the reports of the fishermen, it occurs at all seasons around the shores of Novaia Zemlia.

Phoca lagurina (the hare-like seal) frequents also the shores of the White Sea. It is found also on the coasts of Iceland, and within the polar circle at Spitzbergen and Kamtchatka.

Phoca grisea (the grey seal) is common on the northern shores of Europe, and is frequently observed among the Hebrides, the Orkneys, and Shetland Islands.

Phoca ursina (the sea-bear, ursine seal, or fur seal), is at present exclusively confined to the Behring Sea, between Asia and America, where it is captured chiefly around the Commodore and Pribuiloff Islands, and the Island of St Paul. Formerly a great many sea-bears were found in the Gulf of St Francisco, on the coast of Brazil ; but the seal hunters of the United States have entirely extirpated them.

Phoca jubata, leonina (the lion seal, or sea lion), occurs in Behring Sea, and on all the islands and coasts of the Pacific Ocean, from latitude 61° north (it is sometimes found, though more rarely, at Stuart Island, latitude 63° 30' north), southwards to the Kurilian Islands and Jesso ; and occasionally at the Ladrones or Mariana Islands, in latitude 15° north. The principal gathering-place of the sea-lion is at the Island of St George, the southernmost of the Pribuiloff Islands, latitude 56° north. None of this species are found in the Sea of Penjinsk, on the west side of Kamtchatka.

The second group of *Pinnipedia*, that of the *morses*, consists of a single genus, and this, again, of a single species, namely :—

Trichechus rosmarus, (the walrus), which is usually met with in the seas between Greenland, Spitzbergen, and Novaia Zemlia, in Baffin Bay, from latitude 64° north, in Fox Channel, and in Behring Sea, from the north coasts of Alaska to the Asiatic coast of Behring Strait. It also occurs at the Magdalene Islands, in the Gulf of St Lawrence, and is seen, though rarely, on the shores of the British Islands. One specimen was killed in the Island of Harris, in 1827, and another at the Orkneys in 1825.

EXPLANATION OF THE MAP.

The explanatory notes given on the map itself, and the references made to its contents throughout the preceding pages, render any lengthened description of its objects unnecessary. The following additional remarks, however, may be found useful :—

I. In the synoptical tables inserted in the different provinces, on the upper division of the map, the small asterisk (*) indicates, as in the table on page 2 of the text, that the genus before the name of which it is placed belongs exclusively to the province indicated.

II. As in the first Map of Zoological Geography, the limits of distribution of the most important genera and species are defined by lines, and the species belonging to the same genus are uniformly distinguished by the same colours.

III. The typical animals are delineated on the same plan as those in the first map, and show the most characteristic species of all the five families, divided into two groups, namely, those of the Old and those of the New World, with a subdivision of the former, containing all the Carnivora belonging to Great Britain.

All the animals are delineated on the uniform scale of one-thirtieth of nature.

IV. In the lower compartment of the map, the countries in which fur-bearing animals are hunted, are distinguished by colours; and, for want of space, the Latin names of the single species only are given.

ZOOLOGICAL GEOGRAPHY.

MAMMIFEROUS ANIMALS: ORDERS RODENTIA AND RUMINANTIA.

BY GEO. R. WATERHOUSE, Esq.

SECTION I.—RODENTIA (*GNAWING ANIMALS*).

It will be perceived, upon inspecting the List of the Species of Rodents, and the tabular arrangement displaying their geographical distribution and classification, that the species of the same group most frequently have a wide range in the same, or nearly the same, parallels of latitude;[1] but when the species are inhabitants of the high ridges of mountains, they will follow the course of the mountains, though that course may be in the opposite, or north and south, direction.[2] Examples will be found of groups which are for the most part confined to the higher latitudes, reappearing again in low latitudes, but at great elevations.[3] It will further be perceived, that the great mass of the South American Rodents belong to a group which is of a lower grade of organization than the mass of the species of the Old World, and northern parts of the New.—Family SCIURIDÆ. All the aberrant forms of the *Sciuridæ* are peculiar to the northern hemisphere, with the exception of one genus, *Pteromys*, of which one or two species extend a little below the equator, being found in Java and Sumatra. But few species of this family (the highest of the Rodentia) are found in South America, and these belong exclusively to the genus *Sciurus*; they are chiefly natives of the northern portions of the continent. Two, or perhaps three, species occur south of the equator, but on the eastern side of the Andes only. In the southern parts of the Eastern Hemisphere the *Sciuridæ* likewise become rare: Java is their most southern limit in the Indian Archipelago; and in Africa, we find only two species extending as far south as the Cape of Good Hope.—Family MURIDÆ. The characters which are most common to the Rodentia, are in this family most evenly balanced, and hence it may be regarded as the typical family of the order. It has the greatest geographical range, and is the only family aberrant forms of which occur in the southern parts of both hemispheres.[4]—Family HYSTRICIDÆ. As the class Mammalia presents an order which is, for the most part, confined to South America—the order *Edentata*—so the order Rodentia possesses a family which is essentially American—the *Hystricidæ*. Out of about eighty-seven species appertaining to this family, seven only are found out of the South American province, and these belong to the most highly organized divisions of the family.[5] —With regard to the zoological provinces, as indicated by the distribution of the Rodentia, I conceive it is desirable to ascertain, as far as possible, the value, or relative importance, of the divisions which may be formed; and that this end may, to a certain extent, be accomplished by considering them in relation to the rank of the groups which mark them out, and to the proportionate number of species and sections which they have in common. Thus Europe, Asia, Africa, America, and Australia, might, in this point of view, be regarded as but one zoological province, and as distinct from the groups of islands comprehended under the head Polynesia, these islands having no representatives of the order Rodentia, at least none but such as there is good reason to believe have been introduced by shipping; whilst the different quarters of the globe included in the first provinces have each numerous representatives of the group under consideration. This great province, might then (so far as the Rodents are concerned), be regarded as of a rank equal to that of the order Rodentia.—Descending from the order to the families into which it is divided, we should find in Australia a province of inferior rank, but one next in importance, since, whilst each of the other quarters of the globe included in the first province possesses species of *all* the families of the order, in the Australian district the order is represented by species of *one* family only. South America would become a province of the third degree of importance, one equal in rank to a sub-family,[6] being characterized by the possession of several sub-families which are peculiar to it. The north polar regions of both hemispheres would form a province of low rank, characterized by the presence of certain species in common. North America, generally, might be linked together with Europe and North Asia, by the presence of numerous genera in common;[7] but the zoological affinity (if I may so speak) of the two hemispheres will be found to decrease in proportion as the parts are more remote from the polar region. By degrees new genera make their appearance, the whole of which are distinct, if those of one hemisphere be compared with those of the other. Although distinct, however, it is interesting to observe, that frequently they present the same kind of modifications—adaptive modifications in distinct types. Thus the genera *Dipodomys* and *Macrotarsus* of Mexico (no doubt from the high table-land), are comparable with the gerbois of the central parts of Asia; and the American group, *Geomys*, in like manner, represents the Asiatic section of which *Spalax* may be regarded as the type; whilst for south, where the Hares and Pikas (*Lagomys*) are wanting, we find their analogies in the Cavies and Chinchillas. In about the same parallel of latitude, we find the *Cœnomys* section (the metropolis of which appears to be in Bolivia), and that of *Spalacopus* or *Pseudostoma*, of Chili, representing the genera *Georychus* and *Bathyergus* of South Africa. The genus *Poëcilo* of the Cape, may, in like manner, be compared with that of *Lagostomus* of Patagonia.[8]

TABLE I.—SHOWING THE DISTRIBUTION OF RODENTIA OVER THE GLOBE.

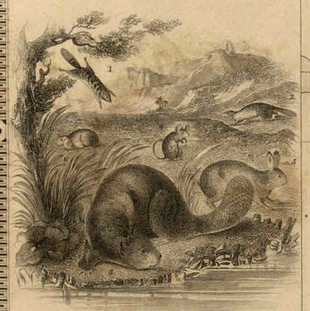
FAMILIES AND GENERA OF RODENTIA, WITH THE Number of their Species.	EUROPE.								ASIA.														AFRICA.										AMERICA.														AUSTRALIA.		ZOOL. PROV. OF THE MAP.					
	Great Britain.	Scandinavia.	Russia, Poland, and Cisalpine.	Prussia.	Germany and Switzerland.	Iberian Peninsula.	Italy, with Isles.	Turkey and Greece.	Siberia.	Turkey.	Mongolia and Manchooria.	Asia Minor and Syria.	Arabia, Persia, Afghanistan.	China.	Japan.	Himalayas and Ceylon.	Malay Peninsula, Sumatra, Java, Borneo.	Eastern Peninsula.	Australia.	Java.	Borneo.	Remainder of Indian Isles.	Barbary.	Egypt.	Nubia, Darfoor.	Abyssinia.	Senegambia, Guinea.	Cape Colony and Interior.	Madagascar.	Rocky Mountains.	United States.	Canada.	Hudson's Bay Territory.	Greenland.	North America.	Central America, West Indies.	Columbia, Guyana.	Brazil.	Peru, Bolivia, Chile.	La Plata, Paraguay.	Patagonia.	Australia.	Van Diemen's Land.	Australia.	Van Diemen's Land.	Temp. Prov.	Trop. Prov.	South America.	Isth. without Cent. Amer.	Central and S. America.	All Ch.	East Indies.	Australia and Van Diemen's Ld.	Old World.	New World.
	Number of the Species.																																																				
I. SCIURIDÆ, . . 153	1	1	11	2	4	1	1	0	9	2	3	0	3	6	3	10	14	10	11	11	5	5	1	.	.	4	15	2	1	10	19	28	8	2	4	5	2	.	.	.	.	.	.	49	11	86	11	10	45	94	59
1. Sciurus, . . . 91	1	1	2	1	1	1	1	1	.	.	1	1	6	1	6	7	12	7	7	10	4	1	.	.	.	4	10	2	1	4	12	11	3	2	4	5	3	.	.	.	.	.	.	24	2	12	11	16	32	.	.	57	34
2. Pteromys . . . 26	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	2	4	1	1	.	.	.	.	.	2	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	17	2
3. Anomalurus . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
4. Tamias . . . 6	.	.	.	.	.	.	.	.	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	4	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.
5. Spermophilus . . 21	.	.	5	.	.	.	.	.	4	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	11	4	3	.	.	.	10	11
6. Arctomys . . . 8	.	.	1	.	1	.	.	.	2	.	1	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	3	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	3	2	3	.	.	1	3	3
7. Aplodontia . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	1	1
8. Castor . . . 2	.	.	1	1	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	1	1
(SPECIMENS UNCERTAIN) 16																														2	4	2	0	8	1									16							16
9. Dipodomys . . 1																																		1										1							1
10. Macrotarsus . 1																																		1										1							1
11. Heteromys . . 2																																		1	1									2							2
12. Saccomys . . 1																																		1										1							1
13. Pteogaulax . . 1																																		1										1							1
14. Geomys . . . 10																																		2	1	1								10							10
II. MURIDÆ, . . 306	10	10	99	12	15	10	12	6	27	17	4	11	14	2	7	17	8	6	6	6	2	5	13	15	16	13	6	35	2	8	38	4	3	5	3	2	.	.	.	.	.	.	59	44	61	77	75	37	21	101	114
SECT. 1. HYSTRINA.																																																				
15. Sphiggurus . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
16. Coendou . . . 10	1	1	3	3	3	2	2	2	2	.	.	1	.	.	.	1	.	.	.	.	.	.	.	1	1	.	1	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	2	.	.	.	.	10	2
17. Erethizon . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
18. Dasyprocta . . 8	.	.	.	.	.	.	.	.	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.	.	.	.	.
19. Dipus . . . 6	.	.	3	.	.	.	.	.	3	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.
20. Jaculus . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
21. Pedetes . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
SECT. 2. CYRTOGASTRINA.																																																		
22. Cheiodactylus . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
SECT. 3. MURINA.																																																		
23. Saccophorus . . 3	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.
24. Mus . . . 75	5	5	7	5	5	6	4	6	5	6	3	5	2	4	2	10	4	2	2	0	2	3	2	3	1	2	1	4	2	2	2	2	2	2	2	2	2	1	1	1	1	1	2	2	2	7	15	4	26	14	16	66	9
25. Mus (Isomys, Sunder.) 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
26. Mus (Akodon, L. Gerf.) 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.
27. Mus (Gerbonda, Gray) 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
28. Mus (Vandeleuria, G.) 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
29. Mus (Nesokia, Gray) 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
30. Deomyscus . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
31. Pelomys . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
32. Otomys . . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
33. Hapalotis . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
34. Pithecheir . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
35. Otenomys . . 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.
36. Hesperomys . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
37. Phyllotus . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
38. Gerbillus . . 24	.	.	.	3	.	.	.	.	.	.	.	1	.	3	.	.	.	.	.	.	.	.	3	4	1	1	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	14	3	.	10	1	.
39. Psammomys . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
40. Meriones . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
41. Ctenodactylus . 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.
42. Gerbillus . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
43. Dendromys . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
44. Dendromys . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
45. Mystromys . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
46. Hydromys . . 8	.	.	.	.	.	.	.	.	4	4	.	.	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	5	3	.	.	8	.
47. Crateromys . . 8	.	.	.	5	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	8	.
48. Hesperomys . . 60	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	24	11	4	9	.	.	.	.	.	.	1	.	45	10	.	.	.	60
49. Hesperomys . . 18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	10	1	7	.	.	.	.	.	.	.	2	.	3	1	.	.	.	18
50. Reithrodon . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	.	.	2	.	.	.	.	2
51. Tachyoryctes . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
52. Heteropelaates . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
53. Ellobius . . 2	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
54. Onomasticeres . 1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
55. Spalax . . . 1	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
56. Siphonæ . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
SECT. 4. ARVICOLINA.																																																		
57. Arvicola . . 26	4	5	5	4	3	2	2	2	2	1	1	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	18	11	9	2	.	.	17	9
58. Lemmus . . 5	.	.	1	3	.	.	.	.	.	1	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	0	2	.	.	.	.	.	.	.	.	.	.	.	.	2	.
59. Fiber . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
SECT. 7. BATYERGINA.																																																		
60. Georychus . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
61. Bathyergus . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
III. HYSTRICIDÆ, . 83																																																		
SECT. 1. HYSTRINA.																																																		
62. Hystrix . . . 9	.	.	.	.	.	1	1	1	.	.	.	.	.	.	.	.	1	.	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	.	.	.	9	.
63. Atherura . . 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.
64. Erethizon . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
65. Chætomys . . 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.
66. Sphiggurus . . 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.
67. Cercolabes . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
SECT. 2. DASYPROCTINA.																																																		
68. Dasyprocta . . 19	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	19	.
69. Coelogenys . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
SECT. 3. ECHINOMYINA.																																																		
70. Echimys . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
71. Carterodon . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
72. Nelomys . . 11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	8	.	.	.	.	.	.	.	.	.	.	.	.	11	.
73. Ischyrs . . . 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	0	2	.	.	.	.	.	.	.	.	.	.	4	.
74. Echinys . . . 6	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	6	.
75. Dactylomys . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
76. Mesomys . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
77. Cercomys . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
78. Petromys . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
79. Capromys . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.
80. Plagiodontia . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
81. Myopotamus . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
SECT. 4. OCTODONTINA.																																																		
82. Octodon . . . 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	.	.	.	.	.	.	.	.	.	.	.	.	3	.
83. Schizodon . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
84. Spalacopus . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
85. Octomys . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
86. Habrocoma . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	2	.
SECT. 5. CHINCHILLINA.																																																		
87. Eriomys . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
88. Lagidium . . 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	2	.
89. Lagostomus . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
SECT. 6. CAVIINA.																																																		
90. Cavia . . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
91. Cavia . . . 8	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	3	1	1	.	.	.	.	.	.	.	.	.	.	6	.
92. Hydrochœrus . . 1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.
IV. LEPORIDÆ, . . 46	4	2	4	3	3	3	3	3	1	0	1	3	1	1	0	1	1	1	0	3	.	.	1	.	.	.	4	.	.	5	7	8	2	.	.	1	1	1	.	.	.	.	.	.	14	5	10	1	7	4	30	16
94. Lepus . . . 37	4	2	3	2	3	2	2	1	1	2	.	1	1	1	0	3	1	1	2	3	.	.	1	.	.	.	4	.	.	4	7	8	2	.	.	1	1	1	.	.	.	.	.	.	13	5	6	1	7	4	22	15
95. Lagomys . . 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	.

ZOOLOGICAL GEOGRAPHY

SHEET No 23

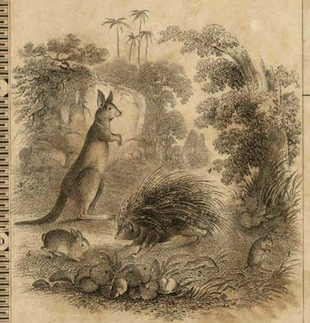
TYPES OF RODENTIA

Scale 1/20 of Nature



NORTH AND SOUTH AMERICA

1 Pteromys Sabrinus (Rocky mountain Flying Squirrel)
2 Arctomys Empetra (Quebec Marmot)
3 Castor Fiber (Beaver)
4 Erethizon (Canadian Porcupine)
5 Lepus Brasiliensis (Tapeti)
6 Cavia Aperea (Com. Guinea Pig)



AFRICA

1 Dipus Aegyptius (Egyptian Jerboa)
2 Mus Barbarus (Barbary Mouse)
3 Pedetes Caffer (Cape Leaping Hare)
4 Hystrix cristata (Common Porcupine)
5 Lepus cuniculus (Common Rabbit)

TYPES OF RODENTIA

Scale 1/20 of Nature

EUROPE

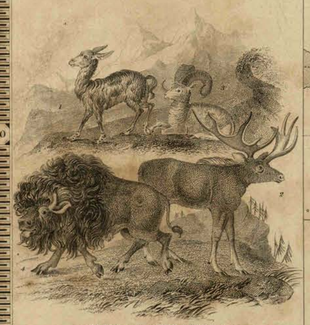
1 Sciurus vulgaris (Red or Common Squirrel)
2 Myoxus avellanarius (Com. Dormouse)
3 Mus Messorius s. minutus (Harvest M.)
4 Mus sylvaticus (Field Mouse)
5 Cricetus frumentarius (Hamster)
6 Arvicola amphibius (Water Rat)
7 Lepus timidus (Common Hare)

ASIA

1 Sciurus Indicus (Malabar Squirrel)
2 Mus dewmanus (Brown Rat)
3 Spalax typhlus (Mole Rat)
4 Lagomys pusillus (Dwarf Pika)

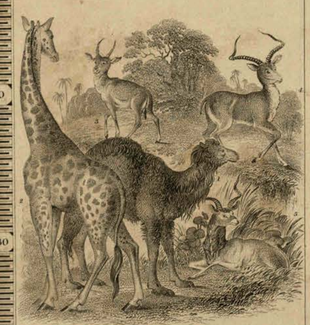
TYPES OF RUMINANTIA

Scale 1/60 of Nature



NORTH AND SOUTH AMERICA

1 Auchenia Llama (Brown Llama)
2 Cervus Ibex Americanus (American Elk or Moose Deer)
3 Ovis montana (Rocky mountain Sheep or Argali)
4 Bos Americanus (American Bison)



AFRICA

1 Camelus Dromedarius (Arabian Camel)
2 Camelopardalis (Giraffe)
3 Antilope bubalis (Hartebeest)
4 melampus (Pallah)
5 Antilope addax (Addax)

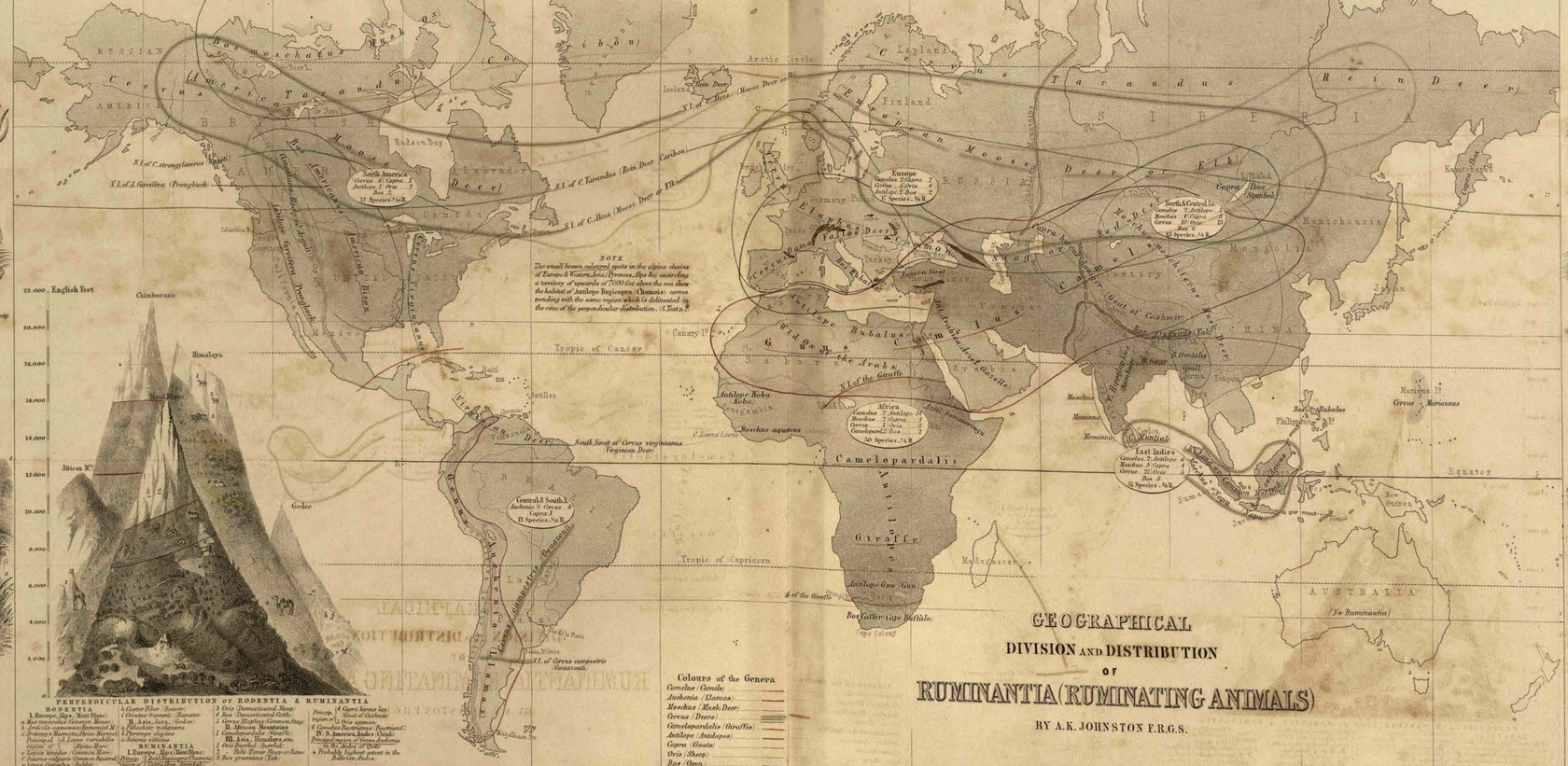

Arctic Circle
Rein Deer
Elk or Moose Deer
Bos moschatus
Cervus Tarandus
Cervus Alces
Cervus Canadensis
Cervus Virginianus
Cervus Strongyloceros
Cervus Furcifera
Cervus Elaphus
Cervus Dama
Cervus Capreolus
Cervus Axis
Cervus Muntjac
Cervus Porcinus
Cervus Hippelaphus
Cervus Moschatus
Cervus Meminna
Cervus Mariannus
Cervus Philippinus
Cervus Equinus
Cervus Hodgsonii
Cervus Eldi
Cervus Duvaucelii
Cervus Aristotelis
Cervus Wallichii
Cervus Leschenaultii
Cervus Unicolor
Cervus Timorensis
Cervus Kuhlii
Cervus Macrotis
Cervus Mantchuricus
Cervus Pygargus
Cervus Sibiricus
Cervus Albirostris
Cervus Yarkandensis
Cervus Wallichii
Cervus Thibetanus
Cervus Affinis
Cervus Cashmirianus
Cervus Hemionus
Cervus Kiang
Cervus Gutturosus
Cervus Picticaudatus
Cervus Chinensis
Cervus Sika
Cervus Nippon
Cervus Pseudaxis
Cervus Porcinus
Cervus Axis
Cervus Muntjac

TABLE II.—*continued.*

			Geographical Distribution.
Genus Notomys, *albipes*	Wagner		South Africa.
Genus Hydromys, *australis* (*chrysogaster* ?)			{ New South Wales, Western Australia, South Australia, and Van Diemen's Land.
Genus Crocidura, *leucodon*	F. Cuv.		In Germany, and the eastern portions of temperate Europe, to the Caucasus; in the west of Siberia to the Obi, north to lat. 66°. In the Crimea, and in the neighbourhood of the Volga, the Ural and Irtish Rivers.
fennecinus	Pall.	The Haustor,	In the Caucasus.
suaveolens	"		Aleppo.
alpinus	Brandt		On the Oural and Volga Rivers, and extends into Armenia, being found at Erzeroum.
soricis	Waterh.	Golden Hamster,	From the Steppes of the Volga, and from the neighbourhood of the Caspian Sea, found also in Persia.
Auratus	Pall.		On the Irtish River, Siberia.
phæa	"		On the Obi, and in Dauria.
Songarus	"		
furunculus	"		
Genus Hesperomys, *gliroides*	Waterh.	New World Rats,	Maritimo.
gliroides	Desm.		Bahia, Bahia Blanca, and Bolivia.
Brachiurus	D'Orb.		Brazil, Province of San Paulo.
phyllotis	Licht.		Near the Uruguay.
sulphius	"		Bahia, Brazil.
Alapecis	Pictet		Brazil.
leucopus	Waterh.		"
pyrrhorhinos	Neuw.		"
arcticus	Wagner		"
sciureus	"		Brazil, at Rio Francisco.
dorsalis	Neuw.		"
sciurinus	Wagner		"
arvicoloides	Pictet		Bahia, Brazil.
nigrita	Licht.		Rio de Janeiro.
Boliviensis	Waterh.		Bolivia.
lanosus	"		Maldonado, La Plata.
obscurus	"		"
sericeus	"		"
gracilipes	"		"
squamipes	Waterh.		Bahia, Illinois.
rupestris	Gervais		Bolivia.
melanotis	Tschudi		Peru.
brevicauda	"		"
xanthorhinus	Waterh.		Santa Cruz, and Port Desire, Patagonia.
griseo-flavus	"		Rio Negro.
talpinus	"		Santa Cruz.
canescens	"		Port Desire.
Magellanicus	Bennett		Santa Cruz, and Hardy Peninsula, Tierra del Fuego. Port Famine, Straits of Magallanes.
longicaudatus	"		{ Chile; abundant in the wooded country south of Concepcion, and in the Valley of Quillota.
brachiotis	Waterh.		On a small island in Melville Bay, *Clarence Archipelago.*
longipilis	"		Chile, in the provinces of Aconcagua, Valparaiso, and Colchagua.
Darwinii	"		Chile, Coquimbo.
Renggeri	"		Valparaiso.
angustatus	"		Chile, near the Lake of Quintero.
auriculus	Wagner		Brazil.
aurita	Licht.		Bahia, Rio Janeiro—and Paraguay?
cinnamomeus	Pictet		Bahia, Brazil.
auriculus	"		"
cursitans	Wagner		Brazil.
leucogaster	"		"
sericeus	"		"
Subgenus (Nelil.) *typhlops*	"		From Ipanema, Brazil.
Strykeyus	"		"
similis	"		From Barara, Brazil.
brevirostrum	"		"
musculoides	"		From Rio Parana, Brazil.
	"		From Lafrador.

South American Muridæ, which have been described as members of the Genus Mus, but which require further examination.

longicaudus	Rengger		Paraguay.
infemus	"		"
ruffus	Desm.		"
spinulosus	"		"
Laticeps	"		"
elegans	"		"
Sanctorum	Licht.		"
squamipes	"		"
hylocrius	"		"
squalinus	Lund		Brazil.
mastacalis	"		"
vellerosus	"		"
longicaudus	"		"
helveps	"		"
cupreus	"		"
bericis	"		"
principalis	"		"
lanosus ?	"		"
Genus Hesperomys (Oxymycterus), *amazonicus*	Waterh.		Maldonado, La Plata.
nasutus	Wagner		Bahia, Brazil.
Genus Hesperomys (Calomys), *elegans*	Waterh.		Bahia Blanca.
limnæbates	"		Maldonado, La Plata.
flavescens	"		Maldonado, La Plata, and Bahia, *Strata.*
murinus	Kerr		North America.
auritus	Bachm.		"
Genus Akodon, *Boliviensis*	Meyen		"
Genus Dactylomys, *parvicus*	Tschudi		Peru.
Genus Reithrodon, *caniculoides*	"		"
typicus	"		St. Cruz, St. Julian, and Port Desire, Patagonia.
chinchilloides	"		Maldonado, La Plata.
Genus Nesoma, *Floridana*	Say et Ord		Southern shore of the S. of Magallanes, near the eastern entrance.
Floridana	"		Florida.
Drummondii	"		Rocky Mountains, Columbia, and California.
Genus Sigmodon, *hispidum*	Say et Ord	Rocky Mountain Mexican, Rough-haired Sigmodon,	Florida.
ferrugineus	Harlan	Rufous,	{ Cotton fields on the Mississippi. (This is probably identical with the preceding species.)

SECT. 3. SPALACINA.

Genus Bathyergus, *suillus*	Gray	Bamboo Rat,	Malacca.
maritimus	"	Chinese Bamboo Rat,	China.
Indica	Hodgs		Lower and central hilly districts of Nepaul, Dargeiling and Sikim.
canescens	Blyth		From Arracan, Ramree.
cinereus	M'Clelland		Tenasserim.
macrocephalus	Rüppell		Patagonia.
Genus Tachyoryctes, *splendens*	Wagner		Abyssinia, in the vicinity of Gondar.
G. Heterocephalus, *glaber*	Rüppell		Shoa, Abyssinia.
Genus Ellobius, *talpinus*	G. Fisch.		{ Temperate Russia, and the west of Siberia, extending northwards to lat. 58°
Genus Cricetodipus, *Parkeri*	Nordm.		{ Found in the Government of Bakutouline, S. Russia, and extends eastwards into the Caucasus, and westwards into Hungary.
Pallasii	K. et Blas.		
Genus Spalax, *Typhlus*	Pall.	Mole Rat,	{ South Russia, from the Volga to the Polish portions; found also in Hungary.
Genus Siphneus, *Aspalax*	Illiger	The Zokor,	Altai Mountains, not extending northwards beyond the 60th lat.

SECT. 4. ARVICOLINA.

Genus Arvicola, *amphibius*	Linn.	{ Water Vole, or Water Rat of England.	{ Found throughout Europe, and in Siberia, extending eastwards as far as the River Lena, and northwards to the Arctic Ocean.
terrestris	"		{ Switzerland, in Alsace, and likewise on the Bavarian Alps, ascending to a considerable height.
ratticeps	Keys. et B.		Russia at Veliki Ustjug (government of Wologda).
nivalis	Martin	Com. Field Vole of Eng.	Snowy regions of the Alps.
arvalis	Pall.		Throughout Europe, and in Siberia.
agrestis	Linn.		Sweden.
neglectus	Thomps.		Scotland (probably the same as the *A. agrestis* of Linnæus).
Sarii	{ Derbyby Lowell.		Italy.
glareolus	Schreb.	The Bank. Vole of Eng.	{ Orcnie in France, Belgium, Holland, Germany, Denmark, and Sweden.
ratticus	Pall.		{ Sweden, Finland, N. Russia and Siberia, and extends into Kamtschatka and the neighbouring islands.
mosorensis	"	Economic Vole,	Siberia.
saxatilis	"		Siberia, the alpine portions.
silimcus	"		Diffused throughout Siberia.
socialis	"		{ Found in the neighbourhood of the Caspian Sea, and extends into Persia and South Russia.
gregalis	"		Eastern Siberia.
Stenocephalus	Licht.		Steppes.
Roylei	Gray		Cashmere.

North American Species.

austrosparsus	Leach	Yellow-nosed Vole,	Hudson's Bay.
Pennsylvanicus	Richards	Wilson's Vole,	United States.
riparius	Ord		"
Carolinensis	Rafinesq.		"
Richardsonii	Richards		"
rufulus	"		"
subrugosus	Wagner		Sebring Strait.
plumbeus	Le Conte		North America, and Georgia.
pinetorum	"		Pine forests of Georgia.
Carolinensis	"		South Carolina.
Sayi	Bachm.		"
Townsendii	"		"
Oregoni	"		Columbia River.
Labradorius	"		"
Austini	Aud. et B.		Long Island, vicinity of New York.
Ochrogaster	"		Western States.
Riparius	"		{ Near Boston, at the Falls of Niagara, and northern parts of New York.
Ossicia	De Kay.		Common in the western parts of the State of New York.
Pennsylvanicus	"		{ Neighborhood of Oneida Lake, and in Hamilton and St. Lawrence counties.
Richardsonii	"		"
Canadensis	"		"
Genus Cricetodipus, *Parkeri*	Nordm.		{ Found in the Government of Bakutouline, S. Russia, and extends eastwards into the Caucasus, and westwards into Hungary.
Pallasii	K. et Blas.		
Typhlus	"	Mole Rat,	{ South Russia, from the Volga to the Polish portions; found also in Hungary.
Genus Siphneus, *Aspalax*	Illiger	The Zokor,	Altai Mountains, not extending northwards beyond the 60th lat.

SECT. 5. DIPODINA.

Genus Dipus, *Sagitta*	Pall.	Common Jerboa,	{ Southern Europe, extending eastwards apparently almost to the Great Mountains.
Telum	"		{ Russia, the Eastern Hemisphere, from the 55th parallel northwards beyond the arctic circle, found in the Altai.
Acontion	"		{ Russia, between the 55th and 65th degrees of north latitude.
Meridianus	Wagner		Sardinia.
cumulus	Licht.	The Common Bobbit,	{ Southern and western parts of Europe, and the greater part of Germany.
Telum	Pall.	The Tebai Hare,	{ Hilly steppes of Daouria and Mongolia.
Tibetanus	Hodgs.	The Tibet	Tibet, central and eastern portions.
Sowerbii	Hodgs.	Sharp-eared	{ Himalaya plains and hill forests, from Simla to Sikim.
Hirtipes	Gray	Hairy-footed	India, Bhotan, Deesah, Jura, and the Mauritius.
rufescens	Fr. Cuv.	Jo. Gerd.	Red-tailed
hispidus	Pallas		Persia.
brachyurus	Temm.	Japan	Japan
Ægyptius	Is. Geoff.	Egyptian	Egypt
lanosiliosus	Desm.	Indistinct	Cheria
Sinaiticus	"	Sinai	Sinai
Syriacus	"	Syrian	Syria
Halonsiliosus	"	Abyssinian	Abyssinia
Arabicus	"	Arabian	Desrts of Arabia, near Gedidah, and in Arabia Felix at Lahsia.
mauritius	F. Cuv.	Long-eared Cape	Cape of Good Hope.
Capensis	Schreb.	Common Cape	"
crassicaudatus	Is. Geoff.	Thick-tailed	"
senegalus	"	Sand	"

American Species.

gliroides	Leach	Polar	{ Found throughout Polar America—extends into Russian America in the west, and even to Newfoundland and the Mean of Maine in the north-east.
Americanus	Erxl.	American	{ Found in the lower mountains of North Virginia; seven Hawks in the States of Massachusetts, New York, Maine, Pennsylvania, and extends northwards to the 60th parallel.
campestris	Bachm.		{ Inhabits the prairies on the Wallawalla, west of the Rocky Mountains, and on the River Platte, on the east side of the mountains (41° 7′ north lat., 12° 45′ east long).
Bachmanii	Waterh.	Bachman's	Carolina.
collaris	Waglor		From Mexico, and the part of California which adjoins.
Californicus	Gray	Californian	California.
Townsendii	Bachm.	Townsend's	{ On the plains eastward of the Rocky Mountains on the Wallawalla.
longimembris	"		Texas.
Richardsonii	"		California.
Artemisiæ	"		{ On the plains of the Wallawalla, west of the Rocky Mountains.
agrestis	"	Marsh	Alabama, Mississippi.
palustris	"	"	Carolina, Georgia, Florida.
sylvaticus	"	"	United States, and southern parts of Canada.
Nuttallii	"	Nuttall's	{ On the banks of several streams which empty themselves into the Columbia, and west of the Rocky Mountains.
Brasiliensis	Linn.	Brazilian	{ Found throughout Brazil, and more likewise in Peru, Bolivia, and Paraguay.
Genus Lagostis, *pusillus*	Cuv.	Piney Lagomys	{ Southern Districts of the Valley; the northern portion of the Great Chain, and in Northern Siberia, extending to Nor Minsk.
alpinus	"	Alpine	Siberia from the 55th eastwards into Kamtschatka.
Ogotona	Pall.	Ogotona	{ Sub-Alpine districts beyond the Baikal, as well as of the Daurian and the Mongolian desert as far as Udon.
Roylii	Ogilby	Roy's	Himalaya—from the Cashmere Range.
rufescens	Gray	Rufous	Cabul.
Nipalensis	Hodgs.	Nepal	Nepaul, northern hilly districts, and Tibet?
Hodgsoni	Blyth	Hodgson's	Himalaya—common in Lahore, Ladakh, and Kashmir.
Curzoniæ	"	Great Chief Hare	Rocky Mountains between the 6th and 10th parallels.
hyperboreus	Pall.	Polar Lagomys	North-east portion of Siberia.

* Besides the above species, some other small Eastern inhabitants of Brazil, have been associated with the *Arvicola*, but without sufficient examination, indeed, we know not yet that they even belong to the species *Muridæ*.

† No doubt most of the above eighteen species will require to be located in the genus *Hesperomys*.

‡ Mr. Darwin states that "near the coast of the Atlantic, the northern limit of the Patagonian Cavy is formed by the Santa Cruz river in lat. 49° 30′ south, where the plains rather suddenly become greener and more humid. The next northern species upon this Strange coast (see Woodcut 32 deg. 30 min.), where the scenery is very similar, the animal again occurs. . . . . Its most northwardly decrease from Santa Cruz Harbour—about 47 deg. 30 min."

§ In extent which, I think, is without doubt specifically identical with the Bennettian Guinea Pig, was brought by Mr. Darwin from Maldonado, La Plata, and that gentleman found the same species common in the neighbourhood of several towns on the banks of the Rio Plata. It inhabits Banda Oriental and Patagonia. Whether the animals bearing the name *C. aperea*, and found in Brazil and in the southern parts of South America, are identical with the southern species, I know not.

¶ Mr. Darwin describes[1] "on the coast side of the South American continent, the Chinchilla ranges from lat. 29 deg. to lat. 32 deg. S., a distance of 1,500 miles. . . . On the east coast it is found from the vicinity of Central Africa to the Rio Negro, in Patagonia, in latitude 41 deg. 10 min. S. In Chile and Peru, as also on the Andean zone of the continent, the genus of Patagonia check its range southwards; as on the Pacific side the cave is of Chile as to the north." I may notice that the animal occurs in Peru and Bolivia; it used to be rare in Paraguay, and was not met with by Prince Maximilian on the east coast of Brazil.

TABLE II.—LIST OF THE RODENTIA, WITH THEIR GEOGRAPHICAL DISTRIBUTION.

I. FAMILY.—SCIURIDÆ (SQUIRREL FAMILY.)

			Geographical Distribution.
A.—European and North American Species.			
GENUS SCIURUS.			
vulgaris,	L.	Common Squirrel,	Europe, Northern Asia, and Japan.
anomalus,	Gmel.	Caucasian Squirrel,	Georgia, subalpine beech and oak forests of Mount Caucasus.
Syriacus,	Ehrenb.	Syrian,	Syria and Arabia.
B.—African Species.			
Stangeri,	Wat.	Stanger's Squirrel	Fernando Po.
rufobrachium,	"	Red-armed,	"
erythrogaster,	"	Red-chested,	"
gambianus,	F. Cur.	Red-bellied,	Fernando Po and Ashanti.
Cepapi,	Smith	Cepapi,	South Africa.
leucotis,	Rüppell	Many-coloured Sq.	Abyssinia.
annulatus,	Desm.	Ringed-tailed,	Gambia and Senegal districts, and Abyssinia.
pusillus,	Desm.	Pygmy,	Ashanti.
Poensis,	Smith	Fernando Po,	Fernando Po.
Temminckii,	"	"	Ashanti.
Congicus,	Kahl	Congo,	Congo.
getulus,	L.	Barbary,	Barbary, Marocco.
albocinctus,	Desm.	White Striped Ground Sq.	Gambia, Senegal, and Abyssinia.
leucogaster,	Licht.	South African Ground,	South Africa.
rutilus,	Rüppell	"	Abyssinia.
Madagascariensis,	Geoff.	Madagascar,	Madagascar.
C.—Indian Species.			
Indicus,	Erxl.	Bombay, or Malabar Sq.	Nearly throughout Hindostan, from Travancore in the South up to Bengal.
Nicobar,	Sparrm.	Blackhead,	Java, Sumatra, Malacca, Siam, Assam, and Nepaul.
ephippium,	Müller	Desm.	Borneo.
Lembanicus,	"	Desm.	Java, Sumatra, Singapore.
auriventer,	Is. Geoff.	"	Sumatra, Siam.
macruropus,	Pennant	Ceylon,	Ceylon.
Kerandiensis,	Lesson	"	Burman Empire.
Siquorus,	Is. Geoff.	"	Java, Sumatra, Borneo, Malacca, Assam, Bhotan.
rufo-niger,	Gray	"	China.
castaneoventris,	"	"	"
Prevostii,	Desm.	"	Borneo, Malay Peninsula, Siam, China.
vittatus,	Raffles	"	Sumatra, Java, Malacca, Canton.
Finlaysi,	Ljungg	"	Java, Sumatra.
nigro-rufulus,	Is. Geoff.	"	Java, Sumatra, Borneo, Canton.
Finlaysonii,	Horsf.	"	Siam, and Sichang Island in the Gulf of Siam.
bicolor-brachyurus,	Müller	"	Borneo.
Philippinensis,	Wat.	"	Mindanao (Philippine Islands).
peguensis,	Is. Geoff.	"	Pegu.
affinis,	Raff.	"	Singapore, the Island of Pule Penang in the Strait of Malacca
cinereus,	Gray	"	Siberia, Northern India.
blanfordanus,	Tenm.	"	Malacca.
castaneoventer,	"	"	"
Lokriah,	Hodgs.	"	Nepaul, Sikim, Assam.
Ludovicianus,	"	"	Nepaul, Assam.
Bicolor,	Gray	"	China.
Berdmorei,	Is. Geoff.	"	Cochin-China.
Malayus,	F. Cur.	"	Java, Sumatra, Borneo.
tristriatus,	Waterh.	"	Forests of the Ghauts.
palmarum,	Linn.	"	Deccan, Calcutta.
subluteolus,	Waterh.	"	Malwa, Nilgherries.
M'Clellandii,	Horsf.	"	Assam and Bhotan.
lemur,	"	"	Singapore.
nembrilis,	Müller	"	Sumatra, Borneo, Malacca.
melanotis,	"	"	Java, Sumatra, Borneo.
exilis,	"	"	Sumatra, Borneo, Malacca.
rubriventer,	"	"	Celebes.
brunneus,	Forster	"	"
marinus,	"	"	"
D.—North and Central American Species.			
capistratus,	Bon.	Fox Squirrel,	Middle and southern parts of the United States. A variety of this species is found in Texas and Mexico.
auduboni,	Bachm.	Golden-bellied Squirrel,	New Orleans and Mexico.
cinereus,	Gmel.	Cat,	Middle and northern parts of the United States.
leucotis,	Gapper	White-eared Grey,	From the middle portions of the United States to Hudson's Bay.
Carolinensis,	Gmel.	Carolina Grey,	From the Peninsula of East Florida westwards into Louisiana, and in the northern direction, extending into North Carolina.
niger,	Linn.	Black,	States of New York and Pennsylvania, and extended into Upper Canada.
Aschobeii,	Bachm.	Larger Louisiana Black Sq.	Louisiana.
fuliginosus,	"	Lesser "	Louisiana, along the banks of the Mississippi.
Hudsonius,	Pall.	The Chickaree,	From the arctic extremity of the woods, southwards to the 40th parallel of latitude—rare below that parallel.
Richardsonii,	Bachm.	Columbia Pine Squirrel	Frequents the pine forests of the Rocky Mountains, west of the great chain.
hemigaster,	"	Downy	North-west coast near Sitka, and at Puget's Sound.
Lewisii,	Smith	"	From the Missouri.
Clarkii,	H. Smith	"	Missouri.
sanrogaster,	F. Cur.	Californian	California and Mexico.
Douglasii,	Gray	Douglas'	Oregon and California.
Collei,	Richards	Colle's	California.
nigrescens,	Bennett	Dusky	"
Bottæ,	Lesson	"	"
mustelinus,	Bachm.	"	"
leporinus,	"	"	North America.
occidentalis,	"	"	"
vexillosus,	"	"	North California.
Bonhami,	Gray	"	Honduras.
Richardsonii,	"	"	"
variegatoides,	Ogilby	"	North-west coast of South America—Mexico?
E.—South American Species.			
Langsdorffii,	Brandt	"	Brazil and Guayana.
variabilis,	Is. Geoff.	"	Peru and Bolivia.
aestuans,	Linn.	Brazilian Squirrel	Guayana, Brazil, Peru, and Bolivia.
stramineus,	Gervais	Geoff.	Peru.
pusillus,	Desm.	"	Cayenne.
igniventris,	Wagner	"	Brazil.
pyrrhonotus,	"	"	"
phrygianis,	"	"	North-west portions of Brazil.
GENUS PTEROMYS.			
leucogenys,	Temm.	Japan Flying	Japan.
sibiricus,	Desm.	"	Java, Sumatra, Borneo, Malacca, Siam.
petaurista,	Pall.	"	From Bengal southwards to Travancore.
Oral,	Tickell	"	Tenasserim, Malacca, Chysticana.
magnificus,	Hodgs.	"	Nepaul, chiefly the central and northern hilly districts.
nobilis,	Gray	"	Nepaul (lower), central, and northern hilly districts, and Darjelling
inornatus,	Is. Geoff.	"	From Coimbatore.
elegans,	Müller	"	Java, and in the Island of Nusa-Kambang, near Java.
sellowiæ,	Gray	White-bellied Flying Sq.	Nepaul.
cinereus,	"	"	Darjelling.
fimbriatus,	"	"	Nepaul.
albiventer,	Hodgs.	"	Nepaul, Darjelling.
Horsfieldii,	Waterh.	"	I. of Banka?
nigritis,	Desm.	"	Java, Sumatra.
cruciatus,	Horsf.	"	Java.
venustus,	Temm.	"	Japan.
volans,	Linn.	"	Siberia.
sabrinus,	"	"	Canada and the United States.
[sabrinus,	Rich.	"	Forests of Canada, the Rocky Mountains, and the far countries up to the 55th parallel.
] Oregonensis,	Bachm.	"	From the pine woods on Columbia River.
GENUS ANOMALURUS.	Waterh.	"	"
Fraseri,	Pelz.	Fraser's Anomalurus,	Fernando Po and Sierra Leone.
Pelii,	Temm.	"	Ashanti.
GENUS TAMIAS.			
striatus,	Linn.	Black-striped Tamias,	(On the Oural Mountains, and throughout the wooded portions of Siberia, as far as the Sea of Okhotsk, and the Amoûr.
Sibiricus,	Pallas	"	From the region of the River Ob. (Eversh.)
quadrivittatus,	Rich.	Four-striped	Far countries of North America, and extends southwards along the eastern declivity of the Rocky Mountains to the sources of the Platte and Arkansas.
Lysteri,	"	Lyster's	Ranges on the eastern side of the Rocky Mountains, from the 50th parallel down to the Carolinas.
lucifrons,	Baikm.	"	North America.
Hindsii,	Gray	"	California.
Townsendii,	Bachm.	Townsend's	Common in woods on the west coast of North America. Plentiful along the banks of the Rio Colorado.
GENUS SPERMOPHILUS.			
fulvus,	Licht.	Fulvous Spermophilus,	On the banks of the northern portions of the River Oural, extending southwards to about the 50th degree.
tesquorum,	Licht.	"	Found between the Caspian Sea and Lake Aral, on the banks of the River Oural, and westwards as far as Saratoff on the Volga.
brevicaudus,	Brandt.	Short-tailed	From the Altai.
undulatus,	Eversm.	Wave-marked	On the River Oural; extends from about the 50th to the 56th degree of north latitude. Common at Orenburg.
caucasius,	Menetr.	"	On the Caucasus Mountains, extending nearly up to the snow line.
Evermanni,	Brandt.	Eversmann's	From the Altai.
Citillus,	Linn.	"	Found in Austria; extends northwards into Silesia, and eastwards through temperate Europe, and into Siberia.
erythrogenys,	Brandt	Red-cheeked	Altai Mountains, and mountains of Baikash.
concolor,	Is. Geoff.	"	Persia, particularly in the great plain of Sultanieh.
xanthoprymnus,	Bennett	Eversmann	Eversmann.
Franklinii,	Sabine	Richardson's	Prairies of the Saskatchewan.
Parryii,	"	Franklin's	"
Richardsonii,	"	Parry's	Prairies, and ranging southwards in Mexico?
Beecheyi,	Licht.	Mexican	Mexico and California.
Douglasii,	Bach.	Douglas'	Banks of the Columbia.
Beecheyi,	"	Beechey's	Upper California.
Richardsonii,	Bennett	Long-tailed	California.
Parryi,	Rich.	Parry's	From the arctic coasts and Rocky Mountains, down to the 56th parallel.
annulatus,	Aud. et B.	Ring-tailed	Western prairies.
lateralis,	Say	Plank-striped	Eastern declivity of the Rocky Mountains, from the 52th degree down to the sources of the Arkansas.
Townsendii,	Bachm.	Townsend's	Inhabits the prairies on the Wallawalla (Columbia River).
GENUS ARCTOMYS.			
Marmotta,	Linn.	Alpine Marmot,	From the Alps.
Bobac,	Schreb.	Bobac	In Poland, Russia, Siberia.
Himalayanus,	Hodgs.	Nepaul	Northern hilly region of Nepaul, and in Tibet.
Tibetanus,	"	Tibet	Tibet. Perhaps the same as *A. Bobac*.
Caudatus,	"	Long-tailed	From the Valley of Gowzlur—Cashmere.
Empetra,	Schreb.	Quebec	Frequents the woods of Canada, and the far countries up to the 60th parallel.
monax,	Gmel.	Hoary	Rocky Mountains.
Canadensis,	Bachm.	Black	From the mountains between Texas and California.
GENUS ARCTOMYSCIA.	Rich.	"	"
Hudsonius,	"	The Sewellel,	New Caledonia, and the banks of the Columbia River.
GENUS CASTOR.			
Fiber,	Linn.	European Beaver,	In the zones of temperate and northern Europe and Asia, between the 55th and 70th degrees of latitude.
Canadensis,	Kuhl	North American Beaver,	Ranges on the eastern side of the continent of North America, from the most northern woods down to the confluence of the Ohio, with Mississippi. Found likewise on the western side of the continent.
FAMILY ——?			
GENUS DIPODOMYS,	Gray		
Phillipii,	"		Mexico.
GENUS MACROTOLUS,	Wagner		
hadiens,	"		Mexico.
GENUS HESPEROMYS,	Desm.		
Tlemquemi,	"		Tehuhuel.
Desmarestii,	Gray		Cuban, Central America.
GENUS SAXIMUS,	F. Cur.		
melanophrys,	"		North America.
GENUS PEDOMYSCUS,	Neuw.		North America, sometimes in the prairies of the Upper Mississippi, as far as the Rocky Mountains.
leucopus,	Rafin.		North America, sometimes in the prairies of the Upper Mississippi, as far as the Rocky Mountains.
GENUS GERBILLUS,	Desm.		Found in the Yellow-stone River; occurs also in the neighbourhood of the Mandan villages?
Tamariscinus,	Pall.		Plains of the Tarkistan town.
Canadensis,	Rich.		Plains of the Columbia, and California?
Sagax,	"		"
Cinereus,	Shaw		Canada.
Hudsonius,	Bach.		Georgia.
Labradorius,	Rich.		Florida.
Leucogaster,	"		Louisiana.
Mexicanus,	Licht.		Mexico.
Quachil,	Gray		Cuban (Central America.)
sylvaticus,	Neuw.		North America, sometimes in the prairies of the Upper Mississippi, as far as the Rocky Mountains.

1 The six genera enumerated under this head are but imperfectly known: the species they contain all possess large cheek-pouches, and are provided with 4-4 molar teeth, unless the *Saccomys Angasii* should therefore be an exception to the dental formula, they have a form of muzzle which approximates more to that of the Mice.

II. FAMILY.—MURIDÆ (RAT FAMILY.)

			Geographical Distribution.
SECT. 1. MYOXINA.			
GENUS MYOXUS.			
avellanarius,	Linn.	Common Dormouse,	In the southern and western parts of temperate Europe.
Japon,	Temm.	Japan,	Japan.
Gruberi,	Wagner	"	From Bonnar.
quercinus,	Linn.	"	In France, the western parts of Germany and Switzerland, and likewise in North Africa, viz., in Tunis and Marocco.
melanurus,	Wagner	Black-Tailed,	Sinai.
Dryas,	Schreb.	"	Southern districts of the Volga, in Georgia, and in Hungary.
Glis,	"	"	In southern and temperate parts of Europe, up to the Volga, and into Georgia.
cinereus,	Rüppell	Ash-coloured,	Near Nubia, South Africa.
murinus,	Desm.	Cape,	Cape of Good Hope.
Gambianus,	F. Cur.	Senegal,	Senegal.
GENUS GRAPHIURUS.			
Capensis,	"	Cape Graphiurus	South Africa.
elegans,	Ogilby	Elegant,	South Africa, west coast.
SECT. 2. DIPODINA.			
GENUS ALACTAGA.			Occurs in Europe in the Steppes between the Danube and the Don, and extends down into the Crimea; ranges eastwards to Barnaul on the River Obi, and in the south-east direction into Great Tartary—if Brandt be correct in regarding the *D. decumanus* and *D. sagittatus* of Lichtenstein, as well as the *D. vagittarius* of Eversmann, as specifically identical with the *Mus Jaculus* of Pallas.
Jaculus,	Pall.	"	West coast of Arabia.
arbusculus,	Wagner	"	In the Steppes of Mongolia.
Indicus,	Elliot	"	From the Steppes between the Danube and Don, and extends through Great Tartary into Afghanistan.
Aeontius,	Pall.	"	In the Kirghis Steppes.
Elater,	Licht.	"	On the east shore of the Sea of Aral, near the River Kowan.
pheruzeus,	"	"	Barbary.
arundinis,	F. Cur.	"	Egypt, between Alexandria and Syouh.
lateralis,	Licht.	"	
GENUS DIPUS.			
Sagitta,	Pall.	"	Between the Don and the Volga, in the southern steppes of the banks of the Irtish, and extends through Songaria into Mongolia.
Ægyptius,	Hasselq.	Egyptian Gerbua	North Africa.
Lichtensteinii,	Licht.	"	On the Upper Nile, from Syene to Dongola, on the west coast of Arabia; and likewise in Tripoli.
macrotarsus,	Wagner	"	Arabia Petræa.
Telum,	Licht.	"	In the Kirghis Steppes north of the Sea of Aral, on the east shores of the Caspian, also in the vicinity of Saratoff, on the River Volga.
Ingressus,	"	"	In Bokhara, near the Sea of Aral.
GENUS JACULUS.			
Labradorius,	Davies	Labrador Jumping Mouse,	North America, from the 58th parallel southwards, into the United States.
GENUS PEDETES.			
Cafer,	Pall.	"	South Africa.
S. 3. CTENODACTYLINA.			
GENUS CTENODACTYLUS,	Gray		
Massoi,	"		North Africa (Tunis and Tripoli).
SECT. 4. MURINA.			
GENUS SMINTHUS.			
betulinus,	Pall.	"	Between the Oural Mountains and the Jenisei, and there appears to be good reason to believe that a small rodent found in Sweden is identical with the present species.
Nordmanni,	Keys. et B.	"	In the Crimea.
vagus,	Pall.	"	Found in Northern Asia between the Rivers Obi and Jenisei, extending as high as latitude 52°, and descends into Tartary.
GENUS MUS.			
A.—European and N. Asiatic Species.			
decumanus,	Pall.	Common Brown Rat	Found in all parts of the world.
Rattus,	Linn.	Black Rat	Found throughout Europe, excepting in the extreme north, and, like the Common Brown Rat, has been conveyed to various parts of the globe. It is, however, less frequently met with than that animal.
Alexandrinus,	Is. Geoff.	"	Tunis, Egypt, Nubia, Italy, and Spain.
Caraco,	Pall.	"	Eastern Siberia.
sylvaticus,	Linn.	Field Mouse	Throughout Europe, and in western Siberia.
musculus,	"	"	Found in all parts of the world.
agrarius,	Pall.	"	From the Rhine, through Germany, into Western Siberia.
minutus,	Pennt.	"	Found in Lisbon.
sylvaticus,	Pall.	Harvest Mouse	Throughout the whole of temperate Europe, and in the temperate parts of Siberia.
Isticus,	Bennett	"	Tredsend.
Abdul,	Aud. et Bach.	"	"
B. Indian Species.			
giganteus,	Hardw.	"	Continental India, Java, and Sumatra.
Perchal,	Shaw	"	Continental India, Java, Sumatra, Celebes, Java.
Indicus,	Is. Geoff.	"	Northern and central hilly portions of Nepaul.
decumanoides,	Hodgs.	"	"
platurus,	"	"	"
speciosus,	Temm.	"	Japan.
terricolor,	"	"	Java.
javanicus,	Müller	"	Sumatra.
flavescens,	Elliot	"	Malwaia country.
Bodoga,	Gray	"	"
Malcolmi,	"	"	"
platythrix,	Bennett	"	Deccan—Malwaia country.
Lepsida,	Gray	"	Malwaia country.
dubius,	Lien.	"	India.
argenteus,	Temm.	"	Japan.
Zanzibaricus,	"	"	"
melleriensis,	"	"	"
proteseus,	Licht.	"	Arabia and Syria.
C. African Species.			
pumilio,	Sparrm.	"	South Africa.
vittatus,	Wagner	"	"
dorsalis,	Smith	"	"
Barbarus,	Linn.	Barbary Mouse,	North Africa—Algiers.
isabellus,	Rüppell	"	Province of Sennin—Abyssinia.
Dembecnicus,	"	"	On the banks of the Dembea Lake, Abyssinia.
hamulosus,	"	"	In house of Monsenah, on the coast of Abyssinia.
abligur,	"	"	Common house-rat at Monsenah, Abyssinia.
Abyssinicus,	"	"	Province of Sennin, Abyssinia.
Alleni,	Waterh.	"	Fernando Po.
Hayi,	"	"	Marocco.
fasciocristis,	Wagner	"	Senaar.
Rufodius,	"	"	"
orientalis,	Rüppell	"	Throughout the north-eastern portions of Africa (Egypt, Nubia, and the coast of the Red Sea).
genilis,	Licht.	"	Egypt and Nubia.
dolichurus,	Smith	"	Cape of Good Hope.
colonus,	Brants.	"	South Africa (Algoa Bay).
Natalensis,	Smith	"	South Africa, near Cape Town.
mossambicus,	Peters	"	South Africa, in the neighbourhood of Port Natal.
silaceus,	Wagner	"	Cafraria.
arcuatus,	"	"	Cape of Good Hope.
minutoides,	Smith	"	"
			South Africa—Caffraland.
D. North American Species.			
Leucopus,	Aud. et B.	"	North America.
Gossypinus,	"	"	"
Carolinensis,	"	"	"
humilis,	Baikm.	"	"
palustris,	Harlan	"	New Jersey and South Carolina.
polionotus,	Wagner	"	Georgia.
Americanus	Desmy.	"	New York.
E. Central American Species.			
Tropilus,	Gray	"	Cuban. (These two species perhaps do not belong to the genus Mus.)
Temanos,	"	"	"
F. Australian Species.			
Australis,	Gray	"	Liverpool plains.
albocinereus,	Gould	"	Van Diemen's Land.
Gouldii,	Gray	"	Moore's River—interior of Western Australia.
hirtipes,	Gray	"	King George's Sound, Bass' Straits, and Van Diemen's Land.
Lineatus,	Waterh.	"	New South Wales, Moreton Islands, and Van Diemen's Land.
Adelaidensis,	Gray	"	New South Wales, South Australia.
Grayi,	"	"	South Australia.
delicatulus,	Gould	"	Port Essington.
tenuicaudatus,	"	"	"
Novæ-Hollandiæ,	Wat.	"	New South Wales.
penicillatus,	Gould	"	Port Essington.
Lineatus,	"	"	Darling Downs.
penicillatoides,	"	"	" (Oakley Creek.)
G. MUS (ISOMYS, SETHERS.)			
hetinotus,	Sanders.	"	Baie of Abiad.
Niloticus,	Is. Geoff.	"	Nubia, Abyssinia, and Arabia.
G. MUS (ALOMYS, I. GEOF.)			
Calabrinus,	Is. Geoff.	"	Egypt.
dissidiatus,	Cretsch.	"	"
remotus,	Wagner	"	Sinai.
G. MUS (MASTOMYS, (GRAY)			
Elliotii,	Gray	"	Malwaia country.
G. MUS (MASTOMYS, G.)			
Coucha,	Bennett.	"	Deccan, Madras, and Nepaul.
G. MUS (NOMISCIA, (GRAY)			
Hardwickii,	Gray	"	India.
Kok,	"	"	Malwaia Country.
hydrophilus,	Hodgs.	"	Northern and central hilly districts of Nepaul.
GENUS DENDROMYS.	Smith	"	
mesomelas,	Licht.	"	South Africa.
undulatus,	Peters	"	"
GENUS PITHECHIRUS.	F. Cur.	"	Java and Sumatra.
melanurus,	"	"	
GENUS CRICETOMYS.	Waterh.	"	Gambia district, Western Africa, and Fernando Po.
GENUS HAPALOTIS.	Licht.	"	New South Wales, Western Australia and South Australia.
albipes,	Gould	White-footed Hapalotis,	Western Australia—neighbourhood of Moore's River.
longicaudatus,	"	Long-tailed	New South Wales.
murinus,	"	Murine	South Australia, and Western Australia, in the neighbourhood of Swan's River.
Mitchelli,	Ogilby	Mitchell's	
GENUS PHLŒOMYS.	Waterh.	"	
Cumingii,	"	Cuming's Philomys,	Island of Luzon (Philippines).
GENUS GERBILLUS.			
Indicus,	Hardw.	Indian Gerbillus,	Found almost throughout Hindostan, extending from Bengal southwards in Travancore.
Cheriei,	Waterh.	Cherie's	Madras.
cheela,	Gray	"	India.
erythrourus,	"	"	Afghanistan.
afer,	"	"	South Africa—vicinity of Cape Town.
meridianus,	Smith	"	South Africa, near the sources of the Orange River.
pygargus,	F. Cur.	"	Senegal.
Libycus,	F. Cur.	"	South Africa—Egypt and Arabia Petræa.
Burtoni,	F. Cur.	"	Darfour.
pyramidum,	Is. Geoff.	"	Egypt.
tenuis,	Smith	"	South Africa—to the north of Lutakoo.
antinoëlis,	"	"	South Africa, eastern district, principally north of the Orange River.
Ægyptius,	Desm.	"	Tunis, Tripoli, Egypt, and Nubia.
tamarix,	Hemp.	"	Sinai.
crassus,	Sundev.	"	Arabia Petræa.
cæsticeps,	"	"	Bahr el Abiad.
surdus,	"	"	"
nanus,	Wagner	"	Syria.
aquaticus,	"	"	West coast of Arabia.
longicaudis,	Desm.	"	Algiers (and Tunis?)
pallidus,	Wagner	"	South-east portions of Russia.
Paulinæ,	Pall.	"	Vicinity of the Caspian Sea.
meridianus,	"	"	"
Hirtipes,	Wagner	"	Abyssinia.
GENUS PSAMMOMYS.			
obesus,	Rüppell.	"	Egypt, Alexandria, and Tunis.
GENUS MALACOTHRIX.			
albicaudata,	Smith	"	South Africa—at Graham's Town, and north of the Orange River.
typica,	"	"	South Africa, district of Graaf, Reynet.
GENUS ECHIMYS.			
brevicaudatus,	Licht.	"	South Africa, near Cape Town.
Smithii,	Smith	"	Interior districts of South Africa—common in certain parts towards the north of the Orange River.
Capensis,	"	"	South Africa.
			Central and eastern districts of the Cape Colony.

SECTION II.

RUMINANTIA (*RUMINATING ANIMALS*).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The order Ruminantia is distinguished from all the other orders of Mammalia, by the existence of four stomachs, arranged for the act of ruminating or chewing the cud. These animals are essentially herbivorous, and are all possessed of the cloven hoof; and it is only among them that species are met with whose foreheads are armed with horns. This order, which is one of the most natural and best defined of all the primary groups into which the Mammalia have been divided, is principally represented by the ox, the sheep, the goat, and the deer; but it is usual also to classify with them the giraffe, camels, antelopes, llamas, &c. They are subdivided into 9 genera, comprising in all 148 species, forming about one-tenth of all Mammalia. Following the general law of distribution, the Ruminantia are most numerous in equatorial regions, but, as if created expressly for the use of the human family, they are distributed over all latitudes, in the northern hemisphere at least, from the equator to the regions within the arctic circle; so that, wherever man is found, he is accompanied by those animals most necessary for the supply of his wants and comforts, and most conducive to his progress in arts and civilization. From them he derives a considerable portion of his food and clothing, whether in a savage or a civilized state of society. Their milk, their flesh, their wool, hides, horns, and hoofs, are all converted to his uses; whilst from many of them he derives the most valuable assistance in the labours of the field, and in the transport of commodities. Thus the rein-deer, as is well known, forms the chief comfort, and the principal means of subsistence to the Laplander; and the yak or kash-gow, confers similar benefits on the inhabitants of Tibet and Pamir. Other cattle require the provident care of man to subsist them through the winter, but the kash-gow is left entirely to itself. If the snow on the elevated flats lies too deep for him to crop the herbage, he rolls himself down the slopes, and eats his way up again. The strong, wiry, and pliant hair of its tail is made into ropes, which for strength do not yield to those manufactured from hemp; and the hair of its body is woven into mats. The milk of the yak is richer than that of the common cow.[1] In tropical countries, again, the camel affords to the inhabitants the means of traversing the wide and trackless desert. From this general distribution of the valuable order of animals under consideration we must except the continent of Australia; among the peculiar fauna of that country, as well as in Madagascar, New Guinea, and the greater number of the South Sea islands, no species of this order has yet been discovered.[2]

DIVISION AND INTENSITY OF THE SPECIES.

Asia and Africa contain by far the greatest number of species of the Ruminantia; indeed each of these countries possesses more than one-third of all species, and they form the chief habitat of the numerous genera of Cervus and Antilope, which together comprise more than the half of all Ruminantia. Hence it is not surprising that the Old World, as a whole, should possess such a vast preponderance in species over the New World. This difference, as shown in the last two columns of the following table, being nearly six to one; for while the Old World has 128, the New World has only 23 species. From this table also it will be seen, that the genera Camelus, Camelopardalis, and Moschus are almost entirely peculiar to the Old World, that Auchenia is entirely confined to the countries of South America, and that the genus Cervus is the most widely distributed of all:—

TABLE SHOWING THE DIVISION OF RUMINANTIA OVER THE GLOBE.

GENERA, with the Number of their Species.	Europe.										Asia.											Africa.					America.						Zool. Prov. of the Map.				
	Ireland and Scandinavia.	Sweden and Norway.	Russia and Poland.	Prussia.	Germany, Switzerland, and Austria.	Southern France, Spain, and Mediterranean Italy.	Turkey and Greece.	Steppes, Mongolia, and Japan.	Asia Minor, Syria, Caucasus, and Persia.	Persia.	Tartary.	Tibet.	Steppes, Caucasus, and Siberia.	China and Japan.	Himalayas and Ceylon.	Eastern Peninsula.	Sumatra.	Java, Borneo, and Philippines.	Celebes, Moluccas and Pitcairn Islands.	Barbary.	Egypt.	Nubia.	Abyssinia.	Cape Colony and Interior.	Senegambia and Guinea.	British America.	United States.	Mexico and California.	Central America and West Indies.	Guayanas, Brazil, and Rivers of South America.	Chili, Bolivia, Peru, Ecuador, and New Granada.	Patagonia.	Temp. Prov.	Tropic Prov.	Africa.	East Indies.	Old World.	New World.
	Number of the Species.																																			
1. Camelus (Camels) . . 2	.	.	.	.	.	.	.	1	1	1	2	1	1	1	2	2	.	.	.	1	2	1	1	.	.	.	.	.	.	.	.	.	2	2	.	2	2	.
2. Auchenia (Llamas) . . 3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	.	.	.	.	.	.	.	.	3	.	3
3. Moschus (Musk Deers) . 4	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	2	.
4. Cervus (Deers) . . 38	4	3	4	3	4	3	3	5	.	2	3	5	1	5	3	.	10	1	2	2	3	4	1	.	.	1	.	2	.	6	5	2	2	6	3	1	6	5	10	8	1	21	28	13
5. Camelopardalis(Giraffes) 2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.	.	.	2	.	2	.
6. Antilope (Antelopes) 48	.	1	1	2	1	.	1	1	2	2	1	1	.	3	.	1	.	.	.	2	1	2	4	9	20	1	1	1	.	1	.	.	1	2	2	.	34	6	47	1
7. Capra (Goats) . . 13	.	.	.	1	1	1	1	.	1	.	4	2	3	2	4	1	2	1	.	.	.	1	1	1	1	.	1	.	1	.	.	.	.	2	2	8	1	4	4	12	2
8. Ovis (Sheep) . . . 21	.	.	.	1	2	2	2	2	1	6	8	6	1	5	.	1	.	.	.	1	.	.	.	1	2	.	.	.	.	.	.	.	.	2	2	13	.	18	3	19	2
9. Bos (Oxen) . . . 13	.	1	.	1	1	1	.	.	1	1	1	.	1	4	2	3	.	1	2	3	1	1	1	1	1	2	2	1	.	.	.	.	.	2	2	6	.	2	8	11	2
AMOUNT OF SPECIES. 148	4	5	7	4	9	9	7	8	11	4	16	17	17	7	21	8	6	25	4	6	7	6	7	6	7	8	10	13	22	10	10	3	2	9	7	5	1	116	77	45	12	50	31	128	23
	Europe.							Asia.												Africa.						America.							Zool. Prov. of the Map.				

DISTRIBUTION OF GENERA AND SPECIES.

1. *Camelus* (Camels). The Arabian camel (Djemal of the Arabs), from which the dromedary is only distinguished by higher breeding and finer qualities—both being possessed of only one hump—is a native of Asia, where, from the earliest ages to the present day, it has formed the chief means of communication between the different regions of the East. Its present geographical distribution extends over Arabia, Syria, Asia Minor, to the foot of the Caucasian chain, the south of Tartary, and part of India. In Africa, it is found in the countries extending from the Mediterranean to the Senegal, and from Egypt and Abyssinia to Algiers and Morocco. It is also very abundant in the Canary Islands.

Arabia produces the greatest number of these valuable animals, the province of Nejed being, on this account, entitled *Om el Bel*—the mother of camels; and the camel of Oman is celebrated for its fleetness and beauty. After the conquest of Granada, the Arabian camel was introduced into Spain by the Moors, and at that time it was very abundant in the southern provinces, but this species it is now extinct. The only place in Europe where this camel is now reared is at Pisa, where it was probably introduced during the sixteenth century, and where, in the arid plains of San Rossora, the country bears a faint resemblance to the desert regions of Asia and Africa.

The Bactrian camel (*Camelus Bactrianus*), is distinguished from the former by having two humps on its back, by its hair being more rough and shaggy, and by being stronger and more muscular; it is the camel of Central Asia, being most abundant in the countries to the north of the Taurus and the Himalayan Mountains. It is also found in the Crimea and the other countries bordering on the Caucasian Mountains; but, although it is said by Pallas to occur in a wild state in the Desert of Shamo, and on the borders of China, it is comparatively rare except in the central districts already mentioned, and in south-western Asia it is almost unknown. In most of these countries this valuable servant of man occurs chiefly in a domesticated state.

2. *Auchenia* (Llamas). These "camels of the New World" differ from the former species, in being much smaller, and having no hump on the back; but they bear in other respects a strong resemblance to them, both in external and internal structure. They are confined exclusively to South America, and chiefly to the western chain of the Andes, extending from the woodlands of Peru and Chile, to Terra del Fuego, northwards through Patagonia, Chile, Bolivia, Peru, Ecuador, and New Granada, as far as Caracas in Venezuela. As explained in the notes on the perpendicular distribution of Ruminantia, this limitation is determined by the low temperature of the regions referred to; and to this cause also must be ascribed their occurrence on the plains of the southern extreme of the continent. "Darwin" states, indeed, that this is the characteristic quadruped of Patagonia. "It generally lives," says the same accurate observer, "in small herds of from half-a-dozen to thirty in each; but on the banks of the S. Cruz, we saw one herd which must have contained at least five hundred." They are observed in great numbers on the northern shores of the Straits of Magellan. In the Andes they frequent the woodlands of Peru.[3]

3. *Moschidæ* (Musk Deer). This group of ruminants is distinguished from all others by the absence of true horns. The principal species *Moschus moschiferus* (the genuine musk deer), from which the whole group derives its name, forms an important object of the chase in the countries in which it occurs, on account of the substance called musk, which is secreted in a bladder-formed cavity in the abdomen of the male. Its chief habitat is the mountainous countries of Central and South-Eastern Asia, between China and Tartary, and in the regions extending from Lake Baikal to the Altai Mountains; it is also common in Nepaul, Bhotan, Tibet, and the adjacent countries of China and Tonquin. Of the other six species, four occur in India, Ceylon, Sumatra, and Borneo, and two in the countries of Senegambia, Guinea, and Sierra Leone, in Western Africa.

4. The *Cervidæ* (or Deer family) consists of that order of ruminants which have solid horns or antlers. They are generally remarkable for elegance of form, vigour, and speed. The species are very numerous and widely distributed, but our space will only admit of a notice of a few of the more important of them. The largest of this genus, *Cervus alces* (the elk)—the moose deer of America), is an inhabitant of the colder regions both of the Old and the New World. The European elk, which recent investigation proves to be quite a different animal from the American moose, inhabits the forest regions of Scandinavia, Eastern Prussia, Poland, Lithuania, and Russia, as far as Finland and the White Sea, extending eastward through the countries of Asiatic Tartary and Lake Baikal, and southward, occasionally, to the Caucasus. It does not extend to the north of latitude 64° in the Scandinavian Peninsula; and the elk is now extinct in Scania, the southernmost province of Sweden, where once it was very abundant. The American moose formerly extended as far south as the Ohio and Cape Breton. They are still found in considerable numbers near the Bay of Fundy, but are not known in the State of Maine. From Dr. Richardson, we learn that they frequent the woody tracts, in the fur countries, to their most northern limits; that in the extreme west their highest latitude is shown at Fort Arctic, near the mouth of the Mackenzie River, latitude 69° north; further eastward, towards the Coppermine River, they are not found higher than latitude 65°; on the west, they extend beyond the Rocky Mountains as far as the Attna River, where they were observed by Wrangell, in 1839.

Cervus tarandus (the Rein-deer), a valuable animal, the presence of which so materially enhances the comfort and promotes the civilization of the inhabitants of the polar regions, is widely spread over the northern parts of Europe, Asia, and America. The *Caribou*, or rein-deer of America, occurs in greatest numbers between latitude 63° and 69° north; its southernmost limit being about latitude 50°. In Europe, the rein-deer inhabits Iceland, Spitzbergen, Northern Russia, and Scandinavia; but its chief habitat is in Finmark and Lapland. It is also abundant throughout the greater part of Siberia and Kamtchatka.

Cervus dama (the Fallow-deer). This gentle creature, the principal ornament of our parks, is an inhabitant of several European countries, as far as latitude 59° north. It does not occur in the Russian peer, but is found in Lithuania, Moldavia, and Greece; it is less common in France and Germany than in England, and is abundant in the wooded districts of the centre and north of Scotland. It extends to the north of Persia and China, and is found in the northern part of Africa, as far south as Abyssinia.

Cervus elaphus (the common Stag or Red-deer) is a native of the temperate countries of Europe (excepting Russia proper), from about latitude 63° north in Scandinavia, southward to the Caucasian Mountains. It also occurs in Siberia, from the regions of the Altai Mountains to the Lena River. In Britain, the range of the stag is now limited to the large parks and chases of England, and to the heath-clad mountains of Scotland, where the largest herds, perhaps, occur on the banks of Lochiel in Argyleshire.

Cervus capreolus (the common Roe or *Roebuck*) is one of the smallest and most elegant of European deers. It belongs exclusively to the Old World, and is widely distributed over the temperate regions of Continental Europe, as far as latitude 58° north; and in Asia, eastward to the River Lena, in Siberia, and southward to Armenia and Persia. In England, it is still abundant in the wooded districts of Westmoreland and Cumberland; in Scotland, it is very rare to the south of the Forth, but very abundant everywhere to the north of that river. It is unknown in Ireland.

Of the American fallows, the most celebrated is *Cervus Virginianus* (the Virginian Deer), which occurs in all the countries of the New World, from Canada on the north, to Cayenne on the south, but is most abundant in Virginia and Louisiana. The number of species of this and the other families belonging to each separate country will be readily found by reference to the preceding table.

5. *Camelopardalis* (Giraffe). This singular and celebrated animal forms an isolated genus among the ruminants. It is exclusively confined to the continent of Africa, in which there is now ascertained to be at least two species, one of which (*Camelopardalis antiquorum*) inhabits Nubia, Abyssinia, and the adjacent countries to Lake Tchad; and the other (*Camelopardalis Australis*, Sw.), the southern regions of Africa to the Orange and Lion Rivers, in latitude 29° south.

6. *Antilope* (Antelopes). Of this very extensive genus, Africa, as has been already stated, may be considered as the head-quarters, since, as shown on the map, this continent alone contains thirty-four species; while Asia has ten, Europe two, and America only one. The most celebrated of the whole genus is the European species, *Antilope rupicapra* (the Chamois), which is a denizen of the alpine districts of Europe and South-West Asia, namely, the Alps, Pyrenees, the Tatra, and Grecian Mountains, and among the ranges of the Caucasus and Taurus.

7. *Capra* (Goats). These well-known and valuable ruminants, like the preceding, are inhabitants of the alpine regions of Europe; as well as the Taurus Mountains, and Kamtchatka in Asia, and some parts of Africa.

Capra ibex (the Bouquetin or Steinbok). In the Pyrenees, the Alps, and the mountains of the Tyrol, the ibex frequents the loftiest ranges, in the vicinity of the snow line, and appears to ascend even to a greater height than the chamois. The greatest number of species of the goat family occurs in Asia, one of the most celebrated being the goat of Cashmere, which is also spread over Tibet and the countries of the Kirghiz, to the north of the Caspian Sea.

8. *Ovis* (Sheep). These, the most ancient of our domestic animals, may be traced originally to the countries of Western Asia. They herd in flocks, in a wild state, on the inaccessible mountainous districts of Asia, Europe, Africa, and America. Like the goats, they are most numerous in Asia. America furnishes only two species, *Ovis Californiana* and *Ovis montana* (Rocky Mountain Argali)—the latter of which inhabits the chain of the Rocky Mountains, from about latitude 40° to latitude 60° north. They also frequent the elevated ridges intersecting the country between this mountain range and the Pacific, and they have been observed further to the eastward than the declivity of these mountains, nor are they found in any of the hilly tracts near Hudson Bay.

9. The *Bovinæ* tribe (Oxen). These comprise the largest of ruminating animals, and consist of groups having a greater or less resemblance to the domestic races of oxen. They are widely distributed, either in a wild or domesticated state, over most countries of the globe. *Bos bubalus* (the buffalo), which has been long known as a domesticated animal in India, has spread thence westwards into Egypt, Greece, Italy, and Spain; and eastwards to China, Cochin-China, and the islands of Sumatra, Java, Borneo, and the Philippines. *Bos Caffer* (the Cape buffalo), is a ferocious animal, which congregates in large herds, as described by travellers, in the interior countries of Southern Africa. The New World furnishes two remarkable species of this order—(1.) *Bos Americanus* (the American bison), which, although its range is much circumscribed, still roams in numerous herds over the remote and uninhabited prairie lands watered by the Arkansas, Platte, Missouri, Saskatchewan, and Peace Rivers, to about latitude 64° north; while, on the south, they extend as far as New Mexico and California. (2.) *Bos moschatus, oribe mox.* Blainville (the musk ox). This singular animal is considered by many naturalists as forming an appropriate connection between the sheep and the ox. It is peculiar to the frozen regions of North America; its southern range beginning where the northern limit of the bison terminates, and extending thence (latitude 64° north) over the barren regions of the polar districts to Melville Island; thus attaining, with the rein-deer, the highest latitude of any known species of ruminants.

PERPENDICULAR DISTRIBUTION.

In perpendicular distribution, the order Ruminantia affords the most striking examples of the limitation of certain genera and species to particular mountainous regions, in which alone are combined those thermal and climatological conditions which appear to be necessary for their very existence. Of these we shall note some of the most remarkable examples in the different regions of the globe, explanatory of the diagram on the map.

Europe.—In the Alps, where the line of perpetual snow reaches a height of 8,000 feet, the *Antilope rupicapra* and *Capra ibex* (chamois and steinbok) attain the greatest height of any of the order; their peculiar habitat being between the upper limit of trees and the snow line, which, on the northern declivities, is about 700 feet lower than on the southern. Oxen graze on the Alps at a height of nearly 8,000 feet, and sheep pasture at a still greater elevation. *Capra elaphus* (the common stag) does not ascend higher into the wooded regions than about 7,000 feet, and *Capra dama* (the fallow deer) about 6,000 feet.

Asia.—Here, as in the European Alps, goats and sheep attain the highest elevation. Thus the goat of Cashmere (*Capra hircus laniger*), and the argali (*Ovis ammon*), browse on the comparatively naked table-lands of Tibet, at a height of from 16,000 to 18,000 feet above the level of the sea. The *Ovis poli* (the Pamir sheep or ram) lives at the still greater height of 15,000 feet, in the table-land of Pamir, eastward of Bokhara; and the burrhel (*Ovis burrhel*) inhabits the highest ridges of the Himalayan chain, where it is described as "bounding lightly over the incrusted snows, at an altitude where its human pursuers find it difficult to breathe."[4] A specimen in the Museum of the Zoological Society, London, is said to have been shot near the Boorendo Pass, at an elevation of about 17,000 feet—considerably above the line of perpetual snow; and consequently it attains, with the exception of the llama, perhaps the greatest absolute height of any of the Ruminantia. *Bos grunniens* (the yak or kash-gow) grazes among the snow on the mountains of Thibet. Wherever the mercury in the thermometer does not rise above zero, is a climate for the yak. Indeed, so rigorously is this animal confined to regions of extreme cold, that in the case of two of them being removed to Kabul, though at an elevation of 6,000 feet above the level of the sea, the climate was so ill suited to their nature that they declined as the snow left the ground, and quitted those desolate regions to pasture in the plains; and in Patagonia, the lowness of the temperature permits it to approach the vicinity of the sea. From this it spreads over the elevated regions of the Andes, and in large herds attains, on Chimborazo, the limit of perpetual snow, which there reaches a height of 15,800 feet. On the Bolivian Andes, where the snow line rises still higher, it attains a height of 18,000 feet.

[1] Wood's Journey to the Oxus, p. 321.

[2] It may be necessary again to remind the reader, that in this and the other sheets of the Zoological Division, domesticated animals are not generally taken into account in treating of the distribution of species.

[3] Journal, p. 106.

[4] Wood's Journey to the Oxus, p. 222.

ZOOLOGICAL GEOGRAPHY.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION

OF

AVES (BIRDS).

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I. DIVISION AND DISTRIBUTION OF BIRDS OVER THE GLOBE.

Birds, forming the second class of vertebrated animals, are divided, by Cuvier, into the following six orders:—

1. Rapaces (Plunderers, or Birds of Prey.)
2. Scansores (Climbers.)
3. Oscines (Songsters.)
4. Gallinacese (Gallinaceous Birds.)
5. Grallatores (Waders.)
6. Natatores (Swimmers.)

Great diversity of opinion prevails among naturalists as to the proper division of Birds into families and genera, and such are the inherent difficulties of the subject, that no two writers of eminence are agreed as to the manner in which this ought to be accomplished; but it is enough for our purpose to repeat that *species* alone exist in nature, and form the only sure ground-work for accurate statistical details in zoological geography.[1] Birds are richer in species than any other class of the animal kingdom—amounting, at least, to upwards of 6,000, since this number is contained in the Museum of Berlin alone[2]—an amount which is about four times greater than the class Mammalia. And as it is the most numerous, so also it is, with the exception of Fishes, the most widely distributed of all classes of animals; for while, as we have shown in the previous maps of this division of the Physical Atlas, mammiferous animals and Reptiles are more or less confined to the warm and torrid zones of the earth, Birds are distributed over every part of the globe, from the equator to the poles. At least, in the highest latitudes to which voyagers have attained, the feathered tribes have never been found entirely absent; of these, the sixth class especially, that of the Swimmers, is most prevalent in arctic regions.

DIVISION AND INTENSITY OF THE SPECIES.

The data for the division and intensity of species over the globe, with the exception of Europe, the map of which forms the second part of this subject, are furnished by Pompper's classification, which is arranged according to Cuvier's system.[3] For this purpose, Pompper divides the globe into sixteen provinces, which, according to the zones, are arranged in three groups. These divisions have been adopted without alteration in the map, except in so far as concerns Europe, which, in the general map, is treated as an undivided province. The following table gives the limits and extent of these sixteen provinces, the numbers in which correspond with those on the map:—

ZONES.	AMERICA.	EUROPE AND AFRICA.	ASIA, OCEANIA, AND AUSTRALIA.
NORTHERN FRIGID ZONE,	1. From North Pole to northern boundaries of United States.	4. All Europe.	2. From North Pole to River Obi, and Sea of Ochotsk.
NORTHERN TEMPERATE ZONE,	3. From northern boundaries of United States to northern extremities of the Gulfs of Mexico and California.		5. From River Obi and Sea of Ochotsk to Black Sea and Sea of Japan.
NORTHERN WARM ZONE,	6. From northern extremities of the Gulfs of Mexico and California over Central America and the Antilles.	7. From the Mediterranean to southern Suits of the Sahara and Nubia.	8. From Black and Japan Seas to Arabian and China Seas.
TROPICAL ZONE,	9. From Caribbean Sea to Bolivia and middle of Brazil.	10. From the southern limits of the Sahara and Nubia to the southern boundaries of Lower Guinea and Mozambique.	11. From Arabian and China Seas to Little Sunda Isles.
			12. Oceania, New Guinea, and Isles in North and East.
SOUTHERN WARM ZONE,	13. From Bolivia and middle of Brazil to Bay of Conception and Rio Colorado.	14. From Lower Guinea and Mozambique to Cape Colony.	15. Australia and Isles in East and South.
SOUTHERN TEMPERATE AND FRIGID ZONE,	16. From Bay of Conception and Rio Colorado to South Pole.		

Although the small tables inserted in the map present a complete synopsis of the orders and species in each of the above provinces, it appeared desirable, in order to give a general view of the whole, to compile the following table, in accordance with those inserted in the notes to the other Zoological Maps:—

TABLE SHOWING THE DIVISION OF BIRDS OVER THE GLOBE.

ORDERS.	Zoological Provinces.																
	Southern Frigid Zone.		Northern Temperate Zone.		Southern Warm Zone.			Tropical Zone.					Southern Warm Zone.				A. Temper. and Frigid Z.
	America.	Asia.	America.	Europe.	Asia.	America.	Africa.	Asia.	America.	Africa.	Asia.	Oceania.	America.	Africa.	Australia.	Australia.	America.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		16
	Number of the Species.																
1. Rapaces (Birds of Prey),	10	4	22	54	14	11	26	12	53	11	31	4	3	28	3		3
2. Scansores (Climbers),	3	2	12	23	7	23	8	4	122	27	86	26	18	30	25		3
3. Oscines (Songsters),	14	9	72	186	59	72	67	16	319	113	194	69	52	107	51		5
4. Gallinaceæ (Gallinaceous Birds),	4	5	16	28	8	13	17	29	43	32	72	15	5	14	24		2
5. Grallatores (Waders),	21	24	20	87	28	20	38	23	59	25	50	11	16	30	16		4
6. Natatores (Swimmers),	49	39	26	112	26	15	8	19	26	19	19	6	16	22	30		23
Amount of Species,	103	83	178	490	103	156	164	85	624	211	452	131	110	229	153		46

This table shows the remarkable fact, that whilst, in general, the number of species is greatest in tropical countries, Europe forms such a striking exception, that it possesses more species than any other province, with the exception of that of tropical America, more even than tropical Asia and the Sunda Islands together. Still, however, we perceive that the gross number of species increases in the tropical provinces; and this is the case also with the single orders, except that of the Natatores, which, on the contrary, decreases in the direction of the equator. Europe and tropical America possess the greatest number of Rapaces, whilst the Scansores and Oscines are also most abundant in the latter country. In tropical Asia the greatest number of Gallinaceæ occurs, and the Grallatores and Natatores are most numerous in Europe.

DISTRIBUTION OF SOME OF THE FAMILIES, GENERA, AND SPECIES.

Order I.—Rapaces. Among the family of the *Vulturinæ* the most remarkable is *Vultur gryphus* (Condor or Cuntur), the largest of all flying Birds.[4] The habitat of this Vulture is confined exclusively to the vicinity of the Andes chain in South America, it appears not to extend even to the table-land of Mexico, and is not found in any other part of the globe. According to the observations of A. Von Humboldt, the breeding place chosen by the Condor is at an elevation of from 10,000 to 15,000 feet above the level of the sea, where they may be seen in groups of three or four, but never in large companies, like the true Vultures. They are often seen at a great height, soaring over a certain spot in the most graceful circles. On some occasions, Mr. Darwin remarks, they do this for pleasure, but on others they are watching a dying animal, or the puma devouring its prey. On one occasion, Humboldt saw this enormous bird floating over the summit of Chimborazo, at an elevation of upwards of 22,000 feet, or six times higher than the region of clouds. From these lofty regions he descends only when driven by the pressure of hunger, in order to seek his food on the sultry shores of the sea; where, however, he cannot long remain, since his nature limits him to a temperature which ranges from 25° to 26°. The Condor is distributed over the whole of the Andes chain, on the west side of South America, from the Strait of Magallanes to latitude 7° north, where, in the province of Antioquia, he attains his northernmost limit, probably because here the Cordillera loses its colossal height. On the southern limits of its distribution the Condor quits the Andes chain, and roams over the plains of Patagonia, where he is found at the mouth of the Rio Negro, in latitude 41° south, having wandered 400 miles from the great central line of his habitation in the Andes. *Vultur aura* (urubu), and *Vultur Papa* (King Vulture), are two other South American species, the latter of which extends to Florida and Mexico. *Vultur Jota* (Black Vulture) is distributed over the countries from South Carolina, Savannah and Georgia, in North America, to latitude 41° south, where it abounds in Brazil and La Plata, while it is never found in the desert and arid plains of Northern Patagonia, nor even in Chile. The Vulture which is figured among the types of the Birds of the Old World, *Vultur Kolbii*, is dispersed throughout the countries of Africa and India; it is very abundant in Southern Africa, and occasionally visits the Island of Sardinia.

Order II.—Scansores. The family *Psittacidæ* (Parrots). This extensive and very interesting family, remarkable for the bountiful colours of their plumage, and their power of imitating the human voice, belongs chiefly to the countries within the torrid zone; but they occur also in temperate regions, and are abundant in the Southern Hemisphere, where they are found even in high latitudes, inhabiting not only the southern extremity of South America, as far as the Strait of Magallanes, but Australia, Van Diemen's Land, New Zealand, and even Macquarie Island, latitude 56° south. In the Northern Hemisphere they appear to attain their highest latitude, by the occurrence of the species *Psittacus Carolinensis* (Carolina Parroquet), in the United States, latitude 42° north: where they join the southern limits of the Elder Duck. Another remarkable circumstance in the distribution of this family is, that while nearly forty species occur in the tropical regions of South America, only three species are known to inhabit the opposite coast of Africa, which is situated under the same latitude, and possesses a vegetation almost equally luxuriant. It is doubtful whether they attain, in this continent, the latitude of 30° south.—We shall now refer to two other families, one of which occurs only in the Old, and the other in the New World. The family *Paradiseidæ* (Birds of Paradise), which hold the highest rank among the feathered glories of creation, are limited to a very small district; and it is singular that the most beautiful of nature's productions should have assigned to it a region whose inhabitants are the most rude and savage of the whole human race; for the country of the Papuas—New Guinea, and the neighbouring islands—with the Moluccas and the Aroo Islands, form the exclusive habitat of the Paradiseidæ. They are birds of passage, and change their quarters according to the monsoons.—The family of the *Rhamphastidæ* (Toucans and Araçaris), are all natives of tropical America, between the countries of Guayana and the Rio de la Plata, but chiefly in Brasil, where they live retired in the depths of the forests.

Order III.—Oscines. The family *Trochilidæ* (Humming Birds). These—the smallest and most brilliant of Birds—are all natives of the countries of the New World, being nearly confined to the tropical portions of America. They are most abundant in the islands of the West Indian Archipelago, and on the continent of South America, from the mouth of the Orinoco to beyond the Tropic of Capricorn. But some species are found at a great elevation, and others at a very high latitude. Mr. Bullock observed them on the lofty table-lands of Mexico, and in the woods on the snowy mountain of Orizaba; and Mr. Darwin found a species in the Cordillera of the Andes, at an elevation of 10,000 feet, while they were met with in great numbers near the Strait of Magallanes, flying about in a snow storm; and Captain King discovered two species in the Island of Juan Fernandez. On the north the ruby-throated Humming Bird was found breeding, near the sources of the Elk River, in the plains of the Saskatchewan; and Wrangell, during his travels in 1823, states that this bird occurs at the mouth of the Atna River, but that it is not to be seen farther to the south or west; but Kotzebue remarks that he observed it on the north-western shores of America, in Behring Strait to latitude 61° north.

Order IV.—Gallinaceæ. It will be seen, from the preceding table, that this order is not nearly so numerous in the New as in the Old World. Here the genus *Phasianus* (Pheasant) extends from the regions of the Caucasus, over Tibet, through the whole of Central Asia, the Malay Peninsula, and Cochin-China, to China and Japan, including the islands of Sumatra and Java; while the genus *Pavo* (Peacock), though not so widely spread as the former, yet extends over India, Tibet, China, Japan, and the Indian Archipelago; *Pavo cristatus* (Common Peacock) is a native of India, where it is common in many districts, and abundant in the jungles along the banks of the Ganges, in the forests of Jungletery and Baughalpore districts, and in the dense forests of the Ghauts. *Meleagris gallopavo* (Turkey) is peculiar to the New World. Its native country appears to extend from the north-west territory of the United States to the Isthmus of Panama. It is not found to the southward of this, nor to the westward of the Rocky Mountains. In former times it was common in many parts of Canada; at present it is most abundant in the States of Kentucky, Illinois, and Indiana.

Order V.—Grallatores. The gigantic family *Struthionidæ* (Ostrich, Rhea, Cassowary, &c.), inhabits the countries of Africa, America, Australia, the Indian Archipelago, &c. The African species, *Struthio Camelus* (the Ostrich or Camel Bird of the Arabs), is the tallest of the class to which it belongs, and probably the fleetest of all running creatures, surpassing in speed the fastest horse or the swiftest greyhound. It is spread over the sandy deserts of the greater part of Africa, from the parallel of Bokara in Barbary to the Cape of Good Hope; it appears not to have been observed on the coast of Guinea or on the shores of the Indian Ocean; but it was met with by Adanson in the sandy plains of the Lower Senegal. In Arabia, the Ostrich inhabits the deserts, chiefly in the plains of Nedjed. In ancient times it extended to India, and, in the fifteenth century, it was found on the southern declivity of the Caucasus, and on the shores of the Black Sea. Of the two other species of Struthionidæ belonging to the Old World, *Casuarius Indicus s. Casuar* (Cassowary) inhabits the south-eastern peninsula of Asia and the Indian Archipelago, where it is found in Sumatra and Java, as well as in Banda; and it is very common in New Guinea, and in the dense woods of the

[1] See Notes to Zoological Geography, plate I.

[2] Lesson, who, during ten years, has been occupied in compiling a list of all known living Birds, has enumerated 6,366 species in 1,053 genera.

[3] Die Säugethiere, Vögel und Amphibien nach ihren geographischen Verbreitung tabellarisch zusammengestellt von Dr. Hermann Pompper, Leipzig, 1841.

[4] Mr. Darwin shot one in Patagonia, which measured, from tip to tip of the wings, eight and a half feet, and from beak to tail four feet.—*Darwin's Journal*, p. 102. Humboldt reckons the largest individuals found in the Andes of Quito at fifteen feet, and the smallest about eight and a half feet.—Tableau de la Nature, t. xii. p. 79.

ZOOLOGICAL GEOGRAPHY

SHEET Nº 4.

TYPES OF THE BIRDS OF THE NEW WORLD

Scale = 1/20 of Nature

RAPACES

1 Vultur Gryphus (Condor) 2 Falco Harpyus (Swallow-tailed Hawk) 3 Bubo Virginianus (Virginian Horned Owl)

SCANSORES

1 Pteroglossus Humboldtii (Humboldt's Aracari) 2 Bucco alcyon (Belted Kingfisher) 3 Picus principalis (Ivory-billed) 4 Ramphastos Ambiguus (Maccaw) 5 Crotophaga Ani (Ani) 6 Cuculus Americanus (Yellow-billed Cuckoo)

OSCINES

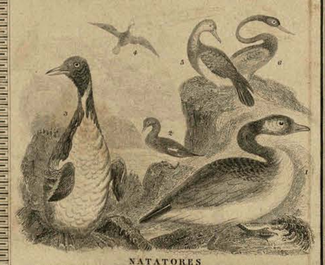
1 Orpheus Polyglottus (Mocking Bird) 2 Turdus migratorius (Migratory Thrush) 3 Hirundo rufa (Barn Swallow) 4 Sitta Carolinensis (White-breasted Nuthatch) 5 Ampelis garrulus (Bohemian Chatterer) 6 Muscicapa tyrannus (Tyrant Flycatcher) 7 Alauda alpestris (Shore Lark) 8 Icterus Baltimore (Baltimore Oriole) 9 Thamnophilus Vigorsii (Shrike)

GALLINACEAE

1 Penelope cristata (Crested Guan) 2 Ortyx Virginiana (Virginian Quail) 3 Meleagris Gallopavo (Wild Turkey) 4 Ectopistes migratoria (Passenger Pigeon) 5 Tetrao umbellus (Ruffed Grouse) 6 Tetrao Urophasianus (Cock of the Plains)

GRALLATORES

1 Mesteria Americana (Ibijau) 2 Ibis Darwinii (Lurving Ibis) 3 Himantopus mexicanus (Mexican Stilt Plover) 4 Rallus Virginianus (Virginian Rail) 5 Totanus semipalmatus (Willet) 6 Scolopax gallinago (Snipe)



NATATORES

1 Anser Canadensis (Canada Goose) 2 Tadorna albeola (Spirit Duck) 3 Aptenodytes Patagonica (Patagonian Penguin) 4 Thalassidroma Wilsonii (Wilson's Petrel) 5 Sula Bassa (Booby or Brown Gannet) 6 Plotus Anhinga (American Darter)

TYPES OF THE BIRDS OF THE OLD WORLD

Scale = 1/20 of Nature

RAPACES

1 Vultur Kolbii (Kolbii's Vulture) 2 Falco Gyrfalco (Gyr or Ice Falcon) 3 Bubo maximus (Great Owl)

SCANSORES

1 Nectarinia pulchella (Purple Bird) 2 Picus viridis (Green Woodpecker) 3 Psittacus erithacus (Grey Parrot) 4 Merops apiaster (Bee eater) 5 Coccothraustes vulgaris (Hawfinch) 6 Cuculus canorus (Cuckoo) 7 Himantopus melanopterus (Stilt Plover) 8 Upupa Epops (Hoopoe)

OSCINES

1 Oriolus vulgaris (Golden Oriole) 2 Regulus flabellatus (Wren-shafted Fantail) 3 Parus major (Great Titmouse) 4 Motacilla alba (Pied Wagtail) 5 Alauda arborea (Woodlark) 6 Hirundo rustica (Barn Swallow) 7 Turdus viscivorus (Missel Thrush) 8 Turdus musicus (Song Thrush) 9 Turdus Merula (Blackbird) 10 Troglodytes parvus (Wren) 11 Philomela luscinia (Nightingale) 12 Emberiza hortulana (Ortolan) 13 Parus caeruleus (Blue Titmouse) 14 Pitta erythrogastra (Red-bellied Pitta)

GALLINACEAE

1 Lagopus mutus (Ptarmigan) 2 Perdix cinerea (Partridge) 3 Phasianus pictus (Golden Pheasant) 4 Turtur riparius (Guillarod Turtle) 5 Gallus gallinaceus (Cock) 6 Pavo muticus (Javanese Peacock) 7 Tetrao Tetrix (Blackcock)

GRALLATORES

1 Platalea leucorodia (Spoonbill) 2 Recurvirostra avocetta (Avoset) 3 Ciconia alba (White Stork) 4 Scolopax rusticola (Jack Snipe) 5 Strethio Cinereus (Heron) 6 Himantopus melanoterus (Stilt Plover) 7 Ardea cinerea (Heron) 8 Vanellus cristatus (Lapwing)

NATATORES

1 Pelecanus onocrotalus (White Pelican) 2 Ardea cinerea (Heron) 3 Anas Boschas (Wild Duck) 4 Mergus Merganser (Goosander) 5 Larus ridibundus (Black-headed Gull) 6 Sterna hirundo (Tern) 7 Procellaria pelagica (Storm Petrel) 8 Colymbus arcticus (Black-throated Diver) 9 Podiceps cristatus (Great Crested Grebe) 10 Phalacrocorax Carbo (Cormorant) 11 Anser segetum (Bean Goose) 12 Cygnus musicus (Whistling Swan) 13 Mergus albellus (Smew) 14 Fulica atra (Coot) 15 Anas Tadorna (Shieldrake) 16 Anas Penelope (Wigeon or Widgeon)

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF AVES (BIRDS) OVER THE WORLD.

List of the Zoological Provinces
Corresponding with the numbers in the synoptical tables

Northern frigid Provinces of	1. America. 2. Asia
Northern temperate Provinces of	3. America. 4. Europe 5. Asia
Northern warm Provinces of	6. America. 7. Africa 8. Asia
Tropical Provinces of	9. America. 10. Africa. 11. Asia 12. Oceania. 13. America
Southern warm Provinces of	14. Africa. 15. Australia 16. America
South temperate & frigid Provs of	The limits of Provinces are colored thus —

EXPLANATION.

These Six Maps are constructed on the same principle as the foregoing Maps of this division. The Zoological Provinces contain synoptical tables of the 6 orders of Birds with the number of their species. In the districts the names of families, genera or species are distinguished by lettes thus. PARADISEIDAE. Paradisea. Paradisea apoda. Epimachus. Epimachus magnus. Lophorina. Lophorina superba. Ptilonorhynchus. Ptilonorhynchus holosericeus. Chlamydodera. Chlamydodera maculata. Sericulus. Sericulus melinus. The districts are colored thus

Rapaces ——— Gallinaceae ——— Scansores ——— Grallatores ——— Oscines ——— Natatores ———

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF THE BIRDS of EUROPE FROM THE LATEST AUTHORITIES BY A.K. JOHNSTON, F.R.G.S.

Explanation of the arrows.
Rapaces
Oscines
Gallinaceae
Grallatores
Natatores

Arctic Circle

Northern Europe
Rapaces 28 Gallinac. 6
Scansores 12 Grallat. 31
Oscines 29 Natator. 69
242 Species

North East Europe
Rapaces 28 Gallinac. 4
Scansores 12 Grallat. 29
Oscines 57 Natator. 55
185 Species

Eastern Siberia
Rapaces 23 Gallinac. 7
Scansores 11 Grallat. 30
Oscines 40 Natator. 59
170 Species

Western Siberia
Rapaces 16 Gallinac. 6
Scansores 7 Grallat. 53
Oscines 31 Natator. 72
202 Species

Central Europe
Rapaces 37 Gallinac. 21
Scansores 14 Grallat. 77
Oscines 223 Natator. 54
305 Species

South East Europe
Rapaces 20 Gallinac. 12
Scansores 10 Grallat. 43
Oscines 47 Natator. 97
250 Species

Central Asia
Rapaces 11 Gallinac. 9
Scansores 7 Grallat. 38
Oscines 50 Natator. 25
139 Species

Southern Europe
Rapaces 41 Gallinac. 21
Scansores 21 Grallat. 54
Oscines 120 Natator. 37
294 Species

South West Asia
Rapaces 20 Gallinac. 14
Scansores 5 Grallat. 54
Oscines 83 Natator. 19
157 Species

India
Rapaces 9 Gallinac. 7
Scansores 4 Grallat. 8
Oscines 21 Natator. 8
32 Species

N. Africa & Arabia
Rapaces 27 Gallinac. 12
Scansores 8 Grallat. 45
Oscines 82 Natator. 27
174 Species

TABLEAU SHOWING THE GEOGRAPHICAL DISTRIBUTION IN → LATITUDE OF SOME OF THE EUROPEAN BIRDS

North Pole

Rapaces
1 Gypaëtos barbatus
2 Circus cinereus
3 Falco tinnunculus
4 Aquila Chrysaëtos
5 Strix Flammea
6 Athene Noctua
7 Milvus regalis
8 Buteo vulgaris

Gallinaceæ
9 Lagopus alpinus
10 Tetrao Urogallus
11 Tetrix

Scansores
1 Picus viridis (Green Woodpecker)
2 Cuculus canorus (Cuckoo)
3 Coracias garrula (European Roller)
4 Upupa Epops (Hoopoe)

Grallatores
1 Ardea cinerea (Heron)
2 Ciconia alba (White Stork)
3 Platalea leucorodia (Spoonbill)
4 Scolopax rusticola (Woodcock)
5 Vanellus cristatus (Lapwing)
6 Charadrius pluvialis (Golden Plover)
7 Totanus calidris (Redshank)
8 Numenius arquata (Curlew)

Natatores
1 Anser cygnoides (Chinese Goose)
2 Anas Boschas (Wild Duck)
3 Mergus albellus (Smew)
4 Sterna hirundo (Tern)
5 Larus ridibundus (Black-headed Gull)
6 Procellaria pelagica (Storm Petrel)
7 Colymbus arcticus (Black-throated Diver)
8 Podiceps cristatus (Great Crested Grebe)
9 Phalacrocorax Carbo (Cormorant)
10 Pelecanus onocrotalus (White Pelican)

RAPACES (Birds of Prey) — SCANSORES (Climbers) — OSCINES (Songsters)

GALLINACEÆ (Gallinaceous Birds) — GRALLATORES (Waders) — NATATORES (Swimmers)

THE PERPENDICULR DISTRIBUTION OF BIRDS IN THE ALPS

Monte Rosa — Mt St Gothard

Rapaces
1 Gypaëtos barbatus
2 Circus cinereus
3 Aquila Chrysaëtos
4 Aquila Fulva
5 " brachydactyla
6 Nyctaëtus Bonapartii
7 Buteo vulgaris

Gallinaceæ
8 Lagopus alpinus
9 Tetrao Tetrix
10 " hemantus

Hospice of St Gothard

Valley of Usern
Rapaces 11 Gallinaceæ 6
Scansores 1 Grallatores 26
Oscines 7 Natatores 8
140 Species

Valley of Rosen

South Europe
Rapaces 41 Gallinaceæ 21
Scansores 21 Grallatores 54
Oscines 120 Natatores 37
294 Species

Central Europe
Rapaces 37 Gallinaceæ 21
Scansores 14 Grallatores 77
Oscines 223 Natatores 54
305 Species

Engraved by W. & A.K. Johnston.

William Blackwood & Sons, Edinburgh & London.

southern coast of Ceram, and also in Bantong, and the Aroo Isles. *Casuarius Novæ Hollandiæ* (Emu or Australian Cassowary) is widely distributed over the southern coast of Australia, and the Islands in its vicinity. They have been observed on the west coast at Swan River; and Captain Flinders found them in great numbers at Port Philip, King George Sound, and on Kangaroo Island, as well as in Carpentaria. In the New World the Ostrich is represented by two species of Rhea; *Struthio Rhea*, and *Rhea Darwinii*—the first, which till recently, was the only species known in America, is the Nhandu Guaçu of Brasil, where, and in Guayana, it is very numerous. It is abundant in the plains of the Rio de la Plata, but has not crossed over the Cordilleras: it has been met with, however, in the plateau of the Uaqualata Mountains, at a height of from 6,000 to 7,000 feet. On the south it appears to extend as far as Rio Negro, in latitude 41° south, followed by the *Struthio Darwinii*. This species, recently observed by Mr. Darwin, extends from the banks of the Rio de Janeiro to the Strait of Magalhaens, in about 54° south latitude.

ORDER VI.—NATATORES. Of this order, one of the most important is genus *Somateria* (Eider Duck), celebrated for the delicate, soft, and elastic down so well known in commerce. Its chief habitat appears to be the shores of the Arctic Ocean. It is abundant on the shores of Davis Strait, Baffin and Hudson Bay, as well as in Greenland, Iceland, Spitzbergen, Norway, and Lapland, and in the islands of Behring, the Kuriles, the Hebrides, and Orkneys; it is less common in Sweden and Denmark, and in Germany it is only observed as a passenger. In America, according to Audubon, it does not range further south than the vicinity of New York. Its southernmost breeding place in Europe is the Fern Islands, on the coast of Northumberland.—The family of the *Spheniscidæ* (Penguins) is most common in the high latitudes of the Southern Hemisphere; it is abundant at the Strait of Magalhaens, the Falkland Islands, the Islands of Tristan da Cunha, Amsterdam Island, Macquarie Island, and the southern shores of Australia; it has been observed even at the Cape of Good Hope, and Lesson killed individuals in 43° S' south latitude, and 57° west longitude.

PERPENDICULAR DISTRIBUTION OF BIRDS.

Birds are the most favoured of all animals in their powers of locomotion, yet they form no exception to the general rule already so often referred to—different species being limited, like the families of plants and quadrupeds, to different regions of the surface of the globe. But their peculiar structure enables them to penetrate, in search of food, into the higher regions of the atmosphere, and to soar above the clouds to such an elevation as man himself cannot boast of.

Birds of Prey ascend highest, and, as we have seen in the preceding notes, the Condor may often cause reach a height of more than 22,000 feet. *Vultur aura* (Turkey Buzzard), *Vultur Papa* (King Vulture), *Vultur Atra* (Black Vulture), occur in the Andes of South America, between the upper limit of trees and the snow line, or at an elevation of from 12,000 to 16,000 feet. In the same region many species of Falcon are found. Among the *Climbers*, *Psittacus militaris* (Green Macaw), attains to an elevation of about 3,000 feet in the Andes. Of the *Songsters*, *Coprimulgus grandis* (Bejan), is found at a height of from 12,000 to 16,000 feet, and the genus *Cinclus*, between 7,000 and 9,000 feet; but the genus *Ampelis* (Chatterers), is never met with higher than 3,000 feet. Among the *Waders*, the Nandu, already referred to, visits the plateaus situated at an elevation of from 6,000 to 7,000 feet; and the genera Colymbus and Anas among the *Swimmers*, reach a height of nearly 10,000 feet in the Andes.

II. GEOGRAPHICAL DIVISION AND DISTRIBUTION OF BIRDS IN EUROPE.

DIVISION AND INTENSITY OF THE SPECIES.

The basis of this representation is the systematic catalogue of European Birds by Keyserling and Blasius,[1] containing in all 400 species, which are divided into 34 families and 164 genera. The names of these families and genera are given in the following table.

Europe is divided into five zoological provinces, of which the Northern and North-eastern extend from the extreme northern regions to latitude 60° north, or rather to the isotherm curve of 41°, while it is divided into an eastern and western portion by a line passing somewhere about the meridian of Archangel. The Central European province extends southward to the crest of the Pyrenees and the Alps, and borders on the South-eastern province, which embraces Southern Russia, and the countries on the north side of the Black Sea, from the Uralian Mountains to the Caspian Sea. The South European province consists of the three peninsulas of Spain, Italy, and Greece, and the islands of the Mediterranean Sea. But the European Birds spread themselves far beyond the limits of their native country, extending southward to the interior of Africa, and many of them over the whole of Asia. For this reason we have extended the map over the adjoining countries to Central and Tropical Asia. In consequence of this extension of European species, Asia forms the second great region, and is likewise divided into five provinces. The two northern provinces, Eastern and Western Siberia, which are nearly divided by the course of the Jenisei River, extend to the same latitude as the two corresponding European provinces, namely, to the isotherm curve of 41°. The province of Central Asia extends southward to the chain of the Himalaya Mountains; and that of South-western Asia embraces the countries of the Caucasus, Asia Minor, Armenia, Syria, Persia, &c., to the chain of the Soliyman Mountains, where the province of Tropical Asia begins. All these divisions correspond with those adopted in the notes to the Map of Carnivora, No. 2 of this division.

TABLE SHOWING THE DIVISION OF THE EUROPEAN BIRDS.[2]

*** The large figures indicate the entire number of species belonging to each order, and the small figures their division in the different regions. For example, in the order Rapaces, the amount of all species is 34, of which, the family Vulturinæ, with the genera Neophron, Vultures, &c., comprises five species, none of which occur in North or North-east Europe, but three in Central Europe, two in South-east, the whole five in Southern Europe &c.

Orders, Families, and Genera, with the Number of their Species.		Europe.					North Africa.	Asia.				
		Northern.	North-east.	Central.	South-east.	Southern.		Western Siberia.	Eastern Siberia.	Central.	South-west.	Tropical Asia or Indic.
		Number of the Species.										
I. RAPACES (BIRDS OF PREY),	34	28	28	31	31	41	21	16	23	15	26	3
1. Vulturinæ (Vultures)—Neophron 1, Vultur 2, Gyps 1, Gypaëtos 1,	5	-	-	3	2	5	3	-	-	1	2	-
2. Falconinæ (Hawks)—Falco 16, Hierax 1, Nauclerus 1, Pandion 1, Circaëtos 2, Pernis 1, Buteo 2, Aquila 3, Haliaëtos 3, Milvus 2, Astur 2, Circus 4,	24	17	20	22	24	28	21	13	16	10	12	4
3. Strigidæ (Owls)—Strix 1, Ulula 4, Asyglius 2, Nyctale 1, Surnia 4, Bubo 2, Ephialtos 1,	12	11	8	12	8	8	3	3	7	3	6	1
II. SCANSORES (CLIMBERS),	23	12	13	14	15	21	9	7	11	9	5	1
4. Cypselinæ (Swifts)—Cypselus 2,	2	1	-	1	-	2	1	1	-	-	1	-
5. Caprimulginæ (Goatsuckers)—Caprimulgus 3,	3	1	1	2	1	3	-	1	2	-	-	-
6. Cuculinæ (Cuckoos)—Cuculus 1, Coccyzus 2,	3	1	2	2	1	3	2	1	1	-	1	-
7. Picinæ (Woodpeckers)—Yynx 1, Picus 8,	9	7	8	7	7	8	-	1	6	4	2	1
8. Alcedinæ (Kingfishers)—Alcedo 2, Merops 2, Coracias 1,	5	1	1	1	5	5	5	3	1	1	2	1
9. Upupinæ (Hoopoes)—Upupa 1,	1	1	1	1	1	1	1	-	1	1	1	-
III. OSCINES (SONGSTERS),	186	70	57	122	100	120	62	34	43	30	65	12
10. Alaudinæ (Larks)—Alaemon 1, Alauda 2, Phileremos 4, Melanocorypha 2,	10	2	3	4	7	8	5	3	1	-	6	1
11. Fringillinæ (Finches)—Plectrophanes 2, Emberiza 13, Passer 2, Pyrrhula 8, Fringilla 14, Coccothraustes 1, Loxia 3,	43	19	11	25	21	21	9	12	15	13	19	-
12. Sittinæ (Nuthatchers)—Angithabus 1, Calamophilus 1, Parus 9, Sitta 3, Rombycilla 1, Garrulus 2, Nucifraga 1, Pica 2, Corvus 6, Pyrrhocorax 1, Fregilus 1,	28	20	13	20	15	18	1	18	12	13	3	-
13. Oscininæ (Songsters)—Sturnus 1, Merula 1, Troglodytes 1, Certhia 1, Tichodroma 1, Cinclus 1, Anthus 2, Motacilla 6, Orioles 1, Petrocichla 2, Turdus 13, Accentor 3, Saliceria 15, Regulus 3, Ficedula 6, Sylvia 12, Luscinia 3, Saxicola 7, Lanius 6, Muscicapa 4,	100	26	28	70	53	70	43	23	14	21	35	10
14. Hirundinæ (Swallows)—Hirundo 5,	5	3	3	3	4	3	4	3	3	2	2	1
IV. GALLINACEÆ (GALLINACEOUS BIRDS),	28	6	4	21	12	21	13	6	4	9	14	2
15. Columbinæ (Pigeons)—Columba 5, Ectopistes 1,	6	-	-	5	4	5	4	2	-	4	4	-
16. Pteroclinæ—Pterocles 2,	2	-	-	2	2	2	1	-	-	-	2	-
17. Gallinæ (Fowls)—Lagopus 3, Tetrao 2, Tetrastes 1, Phasianus 1, Gallus 1, Pavo 1, Meleagris 1, Numida 1, Attagen 1, Perdix 3, Starna 1, Oryx 1, Otygium 1,	18	6	4	16	6	13	8	4	4	5	8	2
18. Otygidinæ (Colins)—Ortygis 2,	2	-	-	-	-	1	1	-	-	-	-	-
V. GRALLATORES (WADERS),	87	32	29	57	64	54	23	30	30	38	32	8
19. Cursitinæ (Runners)—Glareola 1, Cursorius 1,	2	-	-	1	1	2	2	2	-	1	1	-
20. Otidinæ (Bustards)—Otis 3,	3	-	-	2	3	3	2	2	-	2	2	-
21. Gallinulinæ (Gallinules)—Crex 1, Ortygometra 3, Rallus 1, Gallinula 1, Fulica 1, Porphyrio 1,	8	1	1	7	7	8	2	2	-	2	2	-
22. Gruinæ (Cranes)—Grus 4,	4	1	1	1	4	2	2	2	1	3	3	2
23. Plavialinæ (Plovers)—Oedicnemus 1, Haplopterus 1, Vanellus 2, Squatarola 1, Charadrius 1, Eudromias 2, Aegialitis 4, Strepsilas 1, Hæmatopus 1,	14	7	6	8	10	7	5	5	6	6	5	2
24. Scolopacinæ (Snipes)—Recurvirostra 1, Hypsibates 1, Totanus 7, Actitis 3, Phalaropus 2, Limosa 3, Macrorhamphus 1, Machetes 1, Calidris 1, Philomachus 1, Tringa 8, Limicola 1, Ascalaphax 4, Scolopax 1, Nannemius 3,	38	23	21	38	38	19	10	25	22	15	9	2
25. Ibidinæ (Ibis)—Ibis 1,	1	-	-	-	1	-	1	1	-	-	1	-
26. Ardeinæ (Herons)—Ardea 11,	11	1	1	4	10	10	7	6	1	-	6	1
27. Ciconinæ (Storks)—Ciconia 3, Tantalus 1, Platalea 1,	5	-	-	4	4	3	4	2	-	2	3	-
28. Phoenicopterinæ (Flamingos)—Phoenicopterus 1,	1	-	-	-	1	1	1	-	-	1	1	-
VI. NATATORES (SWIMMERS),	112	64	55	54	32	37	23	72	57	23	19	4
29. Anatinæ (Ducks)—Cygnus 3, Anser 3, Chenalopex 1, Vulpanser 2, Anas 7, Rhynchaspis 1, Cairina 1, Somateria 2, Oidemia 3, Undina 1, Glaucion 2, Harelda 3, Fuligula 5, Morgus 4,	44	26	29	24	18	9	6	33	30	14	11	2
30. Pelecanidæ (Pelicans)—Phalacrocorax 5, Pelecanus 3, Sula 1,	9	3	3	3	3	2	2	5	3	1	2	-
31. Podicipidæ (Grebes and Loons)—Podiceps 5, Colymbus 3,	8	5	5	5	4	5	2	7	6	5	2	-
32. Alcinæ (Auks)—Alca 2, Lomvia 1, Morgulus 1, Uria 3,	7	6	7	-	-	-	-	7	7	-	-	-
33. Procellarinæ (Procellarian Birds)—Thalassidroma 3, Oceanites 1, Procellaria 1, Nectris 4,	9	4	1	-	-	-	-	9	3	-	-	-
34. Sternidæ (Terns)—Lestris 4, Larus 18, Sterna 10, Megalopterus 1,	33	13	8	17	12	19	11	18	9	3	3	2
Aggregate of Species,	390	212	185	305	228	297	174	203	170	139	157	32

PERPENDICULAR DISTRIBUTION OF BIRDS IN THE ALPS.

As in the distribution of the fauna of the temperate zone in Europe,* we find this part of our map best illustrated by the judicious remarks on the zoology of the Valley of Ursern, from the observations of the same enlightened naturalist to whom we formerly referred. Schinz remarks, that the highest inhabited valleys, and the Alpine regions of Europe, afford the most interesting opportunities for observations on zoological geography, since the appearances met with there, when compared with those in other situations, may lead to an understanding of the laws which regulate the distribution of animal life over the globe, and especially of that which determines the seasons of the migrations of Birds. Travellers cannot furnish the necessary details; to be of any value, they must, like the following, be the result of many years' observations by a resident on the spot.

The Valley of Ursern, to which these observations apply, is one of the highest inhabited Alpine valleys in Europe, the lowest part of which is 4,040 feet above the level of the sea; and it is surrounded by the highest peaks of the mountain of St. Gothard. A rude and cold climate places it beyond the proper region of trees, which attain nearly their highest limits at the entrance of the valley, and only the hardy pine is able to maintain its existence. Along the banks of the Reiss shrub-like alders and willows occur, but they also cease to grow at a height of 4,870 feet in the Valley of Hospen. At the Hospice of St Gothard, 7,100 feet above the level of the sea, in a valley which for eight months of the year is covered with snow, and where the meadows afford but little shelter, it may be inferred that few animals could find a permanent residence; yet although it is mostly visited by hunting animals and birds of passage, its proper fauna is more numerous than could have been anticipated; and the ornithologist, especially, meets with phenomena which must be new to him. Welden remarks, that in their flight, birds of passage choose the lowest valleys of the Alps, and hence they cannot be so frequently met with in the higher passes; but it is ascertained that the greater number pass over the great St. Bernard, the pass of St. Theodule, the Simplon, and the St. Gothard. The following table† shows the number of species of each of the six orders which inhabit these lofty regions; and the diagram on the map points out the elevation at which they occur, as well as several others which ascend beyond the limits of snow. The list contains 139 species, or nearly one-half of all the Birds, residents or passengers, which occur in Central Europe:—

I. RAPACES.	19	13. Tichodroma,	1	28. Alauda,	1	39. Numenius,	1		
1. Gypaëtos,	1	14. Certhia,	2	29. Parus,	5	40. Scolopax,	3		
2. Aquila,	2	15. Cinclus,	1	30. Hirundo,	3	41. Tringa,	6		
3. Falco,	5	16. Lanius,	4	31. Micropus,	1	42. Vanellus,	1		
4. Strix,	4	16. Sylvia,	16			43. Rallus,	1		
II. SCANSORES,	8	17. Regulus,	2	IV. GALLINACEÆ,	8	44. Crex,	1		
5. Picus,	4	18. Accentor,	2	32. Columba,	2	45. Gallinula,	3		
6. Jynx,	1	19. Anthus,	3	33. Tetrao,	4	46. Morinellus,	1		
7. Upupa,	1	20. Loxia,	1	34. Perdix,	2	47. Phalaropus,	1		
8. Coracias,	1	21. Fringilla,	11			48. Fulica,	1		
9. Alcedo,	1	22. Emberiza,	3	V. GRALLATORES,	26	VI. NATATORES,	7		
		23. Cinclus,	1						
III. OSCINES,	78	24. Turdus,	7	35. Charadrius,	3	49. Anser,	1		
10. Sitta,	1	25. Sturnus,	1	36. Arenaria,	1	50. Anas,	3		
11. Certhia,	1	26. Muscicapa,	3	37. Ardea,	3	51. Podiceps,	1		
		27. Motacilla,	3	38. Grus,	1	52. Larus,	1		

[1] Die Wirbelthiere Europas, von A. Graf Keyserling, und Professor J. H. Blasius. Braunschweig, 1840.

[2] The Births of some of the most important species, in each of the six orders, are indicated by colours on the map, in the same manner as in the other maps of this division; and the names of mountains, rivers, and places, are inserted, when required, to explain them; then it will be found that Fuentabellosa forms the extreme limit of the Golden Eagle in the low lands of France. Doncaster forms the northern limit of the nightingale in Britain, &c.

* For Notes to Map No. 4 of this division, p. 4.

† In this table the classification and nomenclature of Schinz are retained.

ZOOLOGICAL GEOGRAPHY.

THE GEOGRAPHICAL DIVISION AND DISTRIBUTION

OF

REPTILIA (REPTILES).

CLASSIFICATION AND EXTENSION OVER THE GLOBE.

The class of Reptiles—which, of all animals of higher organization, are regarded by man with the greatest suspicion and mistrust, being considered more baneful than useful, more as objects of aversion and dread than of interest and attraction—present by far the most wonderful diversity of form and structure. Thus the difference between the form of the long, trailing snake, and the ponderous, shield-covered tortoise, is much greater than that between the elephant and the mouse, or the eagle and the humming-bird. Reptiles are divided into the following four orders:—*Testudines* (Tortoises), *Sauria* (Lizards), *Ophidia* (Serpents), and *Batrachia* or *Amphibia* (Frogs). These four orders are subdivided into twenty-six families, and these, again, according to different classifications, form from seventy to one hundred genera. The number of living species which are not only known and described, but of which the habitat is ascertained, amounts, according to the most recent calculations, to six hundred and fifty-seven. This is by far the smallest number of species belonging to any of the four classes of vertebrated animals; but it is necessary to bear in mind that the number of those whose habitat is not ascertained must amount to some hundreds more, and C. Bonaparte, in 1832, reckoned the whole at nine hundred and forty-five, including the fossil species.

In regard to the distribution of Reptiles over the globe, a glance at the map will show that they are, to a much greater extent than any of the three other classes of vertebrated animals, limited to the countries of the torrid zone; only a few of the smaller genera occur in the countries of the temperate zone. In fact they can more easily bear the rigours of a severe winter, than suffer the absence of a hot summer; hence in Scandinavia, although the species are very few in number, the individuals are much more numerous than in Britain. Very few species reach the isothermal line of 32°, and still fewer extend beyond it. The Frogs generally extend farthest towards the polar regions; yet a species of Lizard (*L. ocellata*) has been discovered as far north as Kamtschatka, through the southern part of which the isothermal line of 32° passes. Indeed, the common Water Frog (*Rana esculenta*) extends to a much higher latitude in Finland, although it does not reach the isothermal line of 32°. In the New World, the Frogs extend beyond this line in Greenland and British America. On the banks of the Mackenzie River Frogs and Salamanders are known to extend to the 67th degree of latitude, where the mean temperature is not above 7° or 8° of Fahrenheit, and where the cold in winter sometimes descends to more than 50° below the freezing point. The farthest point to which Reptiles have been ascertained to extend in the Southern Hemisphere is latitude 50° south, where, on the banks of the river Santa Cruz, a frog was observed by Mr Darwin.[1] The shadings on the map, too, will indicate that the great river courses, estuaries, and level tracts of continents, together with the smaller low lying islands of tropical seas, are the chief haunts of the Reptilia.

DIVISION AND INTENSITY OF THE SPECIES.

If the Reptile fauna of all countries were as thoroughly known as it is, for example, in the small state of Connecticut, the result attained, as to comparative numbers, would, doubtless, be very different from that we now possess, which gives for Connecticut fifty-six,[1] and for the whole of Asia (with the exception of the East Indies) only forty-four species. In the following table we have attempted to present a complete view of the division of the four orders of Reptiles and their families over the globe, with the exception of the Serpents, of which we shall treat in the second section of this paper. In representing the intensity of species in this map, we have endeavoured to combine the principles adopted in the first two maps of this division. The comparative amount of species is indicated by shading, as in the first, and, at the same time, the world is divided into provinces, in each of which synoptical tables are inserted, as in the second map. The number of provinces in this map is limited to seven, which are divided according to the zones, namely, three Torrid, three Temperate, and one Austral province. These provinces, with the number of species of their entire fauna, are, next to the division of Reptiles over the globe, also given in the annexed table:—

TABLE SHOWING THE DIVISION OF *REPTILES* OVER THE GLOBE.

ORDERS and Families of the REPTILES, with the Number of their Species.	Europe.							Asia.														Africa.									America.																Australia &c.				Zoological Provinces of the Map.						
																															N. America.					S. America.																Temperate Old World.		Tropical Provinces.				
	Great Britain.	Scandinavia.	Russia and Prussia.	France.	Germany and Switzerland.	Austrian Empire.	Spain, with Islands.	Turkey and Greece.	Southern and Central Asia.	Asia Minor.	Arabia and Persia.	Caucasian and Caspian Provinces.	Afghan.	Himalayan and Cashmir.	Birman Empire.	Siamese.	Malay.	Chinese.	Japanese.	Kurile Islands.	Siberia.	Barbary.	Egypt, Nubia, and Abyssinia.	Western and Central Africa.	Cape Colony.	Madagascar.	Mauritius, Bourbon, &c.	Senegambia.	United States.	Mexico and Yucatan.	Central America and West Indies.	Guayana and Columbia.	Brazil.	Paraguay and La Plata.	Chile and Peru.	Australia.	New Guinea.	New Zealand.	Van Diemen, Norfolk Islands, &c.	South America.	Europe.	Asia, without the East Indies.	Africa, without the North Africa.	East Indies.	Australia and Oceania.
	Number of the Species.																																																								
I. TESTUDINES (TORTOISES), **69**	-	-	1	2	1	-	5	3	-	1	1	1	-	7	-	5	10	8	1	6	6	3	4	3	2	3	1	19	4	6	7	15	1	-	3	2	-	23	6	4	18	15	23	5
1. Terrestrial or Land Tort.	13	-	-	-	-	1	2	-	-	1	-	-	-	2	-	1	-	-	-	1	1	-	-	-	-	-	-	-	1	2	1	3	1	-	1	1	-	1	2	1	4	7	2	2
2. Fresh-water Tortoises																																																							
a Marsh Tortoises,	38	-	-	1	2	1	-	2	-	-	-	-	-	3	-	3	5	5	1	2	1	1	-	-	-	-	-	1	14	2	1	3	9	-	-	2	-	-	15	2	2	7	2	11	2
b Flexitelle or River T.	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	2	-	-	1	5	1	-
3. Marine Tortoises or Turtles,	9	-	-	-	-	-	3	-	-	1	1	-	-	2	-	1	-	-	-	3	2	1	2	-	1	1	-	3	1	3	2	3	-	-	1	1	-	3	2	1	6	5	3	1
II. SAURIA (LIZARDS), . . **203**	3	2	2	12	3	14	30	7	5	9	6	9	-	13	1	10	18	10	2	9	24	26	5	17	1	11	2	8	8	12	19	40	2	2	9	3	1	13	29	17	67	67	45	14
4. Crocodilidae (Crocodiles),	13	-	-	-	-	-	-	-	-	1	1	-	2	-	1	2	-	-	-	-	-	1	1	-	-	1	-	1	2	2	1	4	1	-	1	-	-	2	-	1	6	2	4	1
5. Chamaeleontidae (Chameleons), . . .	7	-	-	-	-	1	1	-	-	2	1	-	-	1	-	-	-	-	-	1	3	2	-	-	-	1	4	-	-	-	-	-	-	-	-	1	1	-	-	1	2	-	6	2	1
6. Geckotidae (Geckos), . . .	37	-	-	3	-	2	4	3	-	3	2	-	-	1	-	1	3	1	-	1	4	5	-	1	1	3	-	3	5	3	-	1	2	-	-	-	-	-	4	3	5	11	6	2
7. Iguanidae (Iguanas), . . .	52	-	-	-	1	-	1	1	-	-	3	-	3	1	-	2	5	3	-	4	1	6	1	6	-	1	-	4	2	2	6	6	14	1	-	1	-	-	5	3	-	22	12	17	3
8. Varanidae (Varans, Monitors, &c.), ...	15	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	2	2	1	2	1	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	1	-	1	-	5	7	2
9. Teidae (Tegutinae), . . .	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	5	-	-	-	-	-	1	-	-	-	6	3	-	-	-	-	-	-	-	11	-	-	-
10. Lacertidae (True Lizards), .	26	2	2	1	3	2	4	10	-	1	1	2	-	-	-	-	2	-	-	-	1	5	-	-	-	-	-	1	-	-	-	3	2	-	-	-	-	1	8	5	3	9	2	-
11. Chalcidae (Chalcis, Sauraphis, &c.), ...	12	1	-	1	-	1	2	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1	6	7	-	-
12. Scincidae (Skinks), . . .	39	1	-	-	4	1	5	9	1	2	1	1	-	2	-	3	4	4	-	1	9	5	1	2	1	3	-	2	-	2	1	11	-	1	4	3	-	1	10	3	14	15	7	5
III. OPHIDIA (SERPENTS), (Containing the Families 13-21.)	**265**	3	3	3	8	9	9	11	12	6	5	4	12	6	21	9	20	36	-	16	13	11	10	10	18	6	5	9	28	6	24	48	43	5	7	11	12	2	30	25	15	84	56	105	32
IV. AMPHIBIA (FROGS),	**120**	6	3	4	9	8	6	11	6	3	5	1	1	3	4	-	-	-	-	-	7	2	-	1	-	-	2	28	1	1	21	56	1	2	6	3	-	30	23	8	24	9	6	7
22. Caecilidae (Caecilias), . .	5	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	5	-	-	-	-	-	-	-	-	4	-	1	-
23. Ranidae (True Frogs), . .	84	4	3	3	7	5	4	7	5	2	4	1	1	4	3	2	-	-	-	-	5	2	-	1	-	-	-	3	17	-	1	17	53	1	2	6	3	-	17	13	7	19	7	5	7
24. Salamandridae (Tritons and Newts), ...	20	4	1	1	2	2	2	4	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	1	15	-	-	-	-	-	-	-	-	-	15	9	1	-	2	-	-
25. Amphibamidae (Amphisbaenas, &c.), ...	2	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	2	1	-	-	-	-	-
26. Proteidae (Proteus, Axolotl, &c.),	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-	-	-	5	1	-	-	-	-	-
AMOUNT OF THE SPECIES OF ALL REPTILES, ...	**657**	11	10	10	31	21	29	37	27	11	20	15	24	10	75	10	44	54	18	18	30	48	23	19	29	9	10	9	93	17	43	93	150	9	11	29	22	3	102	73	44	243	143	179	40

The above table shows that the number of species of Reptiles occurring in the countries of the torrid zone is at least double that of the countries of the temperate zone, and that, as in the case of the most of the orders of Mammalia, the exception to this general law is found in the Australian province, which does not contain a third part of the number occurring in the adjoining Tropical province of Asia, nor even as many as are found in Europe. The relative maxima of species are, for the Old World, eighty-four (in Java); and for the New World one hundred and fifty-nine (in Brazil), that is to say, America contains nearly the half of all Reptiles.

In regard to the division of the single orders, we find that the order of the *Tortoises* is most numerous in the United States, in Brazil, and in the Great Sunda Islands. In Africa, the Barbary States contain the greatest number of species, the amount being equal to those inhabiting the whole of Europe, which are almost all found in the countries bordering on the Mediterranean Sea.

Of the two hundred and three species which compose the order of the *Lizards*, by far the greater number occur in the provinces of Africa and South America, each of which contains about one-third; but the relative greatest number of species is found in Brazil, which possesses forty-six, or nearly one-fourth of all the Lizards. To this country the families of the Teguxina, Iguanas, and Skinks are peculiar, and it contains most of the species of Crocodiles. North America possesses, in proportion to the other provinces, as well as to the three other orders, the smallest number of Lizards. In Europe, the greater number of species belongs to the families of the Geckos, True Lizards, and Skinks. Of these together, Italy alone contains seventeen species. In Asia, although the countries of the tropical regions are richer in species than those of the temperate regions, the case is very different in regard to the single families. In Africa the northern countries contain the greatest number of species; the Chameleons, Geckos, Monitors, and Skinks are the characteristic families in this quarter. In Australia and New Guinea the greatest number of species belongs to the Scincidae.

To the most numerous and most important order, that of the *Serpents*, a separate section is devoted, so that they are not treated of in this general view; but, in order to complete the survey, the gross number of their species is quoted in the foregoing table, which shows the very striking result of their division in the two neighbouring islands of Borneo and Java, since in the former not a single species has yet been observed, while the latter contains relatively the greatest number of species of all countries, namely, fifty-six species, or more than one-fifth of all Serpents.

The last and least important order, that of the *Frogs*, is distinguished in its division from the three first orders in this respect, that it occurs in by far the greatest numbers in the New World; for while the Tropical province of America contains seventy-four species, the two corresponding provinces of the Old World have, respectively, only nine and six species; and even these few species generally inhabit the more temperate countries of this province, for on none of the islands of the Asiatic Archipelago has a single frog hitherto been observed. North America and Europe occupy the middle space, between these two extremes. In Europe, the species are very equally distributed.

SECTION I.

DISTRIBUTION OF THE ORDERS AND SOME OF THE GENERA AND SPECIES.

ORDER I.—*Testudines* (Tortoises). The animals of this order are, more than those of any of the others, limited to the countries of the torrid zone. The Marsh Tortoise attains the highest latitude; *Emys Europea* (common Marsh Tortoise), extends to the parallel of 52° north, in the Prussian provinces of Silesia and Brandenburg, while the northernmost limit in North America is formed by a species of Emys frequenting the River Winnipeg, at 50° north latitude. The southernmost limit is formed by a species of the family of Land Tortoises, *Testudo sulcata* (Furrowed Tortoise), which, according to d'Orbigny, is common in Patagonia. The Marine Tortoises, or Turtles, generally termed *Chelonians*, are found on the shores of all the tropical seas, but chiefly within the parallels of 20° north, and 30° south latitude. To the south they are found in Norfolk Island, latitude 29° south; but in the Northern Hemisphere they reach, as occasional stragglers, a much higher latitude. On the Scottish coast, *Sphargis coriacea* (Leathery Tortoise) is found as far north as Massachusetts Bay, latitude 43° north; in the Old World, the same species is frequently met with in the Mediterranean, especially on the northern coast of Africa, and on the shores of Sardinia; it is occasionally captured in the Adriatic Sea, in the River Loire, in Languedoc, Cette, Bretagne, and sometimes on the coast of Cornwall. Once, indeed, a Hawk's-bill Turtle (*Chelonia imbricata*) was caught at Papa Stour, one of the Shetland Islands, in latitude 60° 30′ north; and Fleming, who states this extraordinary case in his excellent "History of British Animals," assigns as the probable cause of its being found there, uncommonly warm seasons, the more or less abundant supply of food, or the prevalence of storms. Perhaps the Gulf Stream may have assisted in the transportation to so high a latitude. The chase of the Hawk's-bill Turtle, which furnishes the horny plates covering the carapace, known in commerce under the name of tortoise-shell, and which affords an important article of trade, is carried on chiefly in two separate regions of the globe. In the Eastern Hemisphere, the principal theatre of this fishery, is in the Moluccas Islands, and on the north-western coast of New Guinea, and in the Western Hemisphere, at Haiti, and particularly at Cuba, and among the Cayman Islands. But the produce of the fishery of the Pacific Ocean is so much more valuable than that of the Atlantic, that while the shell procured by the former brings 60s., the latter is reckoned as worth only 8s. per pound weight.

ORDER II.—*Sauria* (Lizards). The first and most important family of this order, that of the Crocodiles, is divided into three groups, which derive their names from the different parts of the globe in which they are found. The Alligators or Caymans are peculiar to America, the True Crocodiles to Africa, and the Gavials to Asia. The Alligators have the widest circle of distribution, since they extend from latitude 51° south, through Paraguay and Brazil, across Central America and the Antilles, through Mexico, Louisiana, Florida, and Georgia, to Carolina, in latitude 32° 30′ north. The African Crocodiles extend from Congo to Senegambia on the west, and Egypt on the east. The common Crocodile of the Nile is distributed over nearly the whole river district, and though it is no longer found in the Delta, it is abundant in the Upper Nile and its tributaries. Throughout Nubia and Abyssinia. The Asiatic Crocodile extends from the north-west coast of Australia through the Indian Archipelago to Hindustan, where *Gavialis Gangeticus* (Gavial) is found in the Ganges. During the expedition, under Colonel Chesney, in 1835, crocodiles were discovered in the Euphrates River. Of the remaining families, one of the most interesting is that of the Chamaeleons, the habitat of which, as shown by the map, is exclusively confined to the Old World. One of its species, *Chamaleo vulgaris* (Common Chameleon), extends, in the south of Europe, to the southern parts of Spain and Sicily. Some species of the family of Geckos are also inhabitants of the warmer parts of Europe; but of all the families, only the Skinks attain the latitude of Great Britain, *Saxicola agilis* (Land Lizard) extends to Scotland and Ireland. This species is common in France, and in the middle districts of Europe, but it is rare in Italy. Of the Skinks, *Anguis fragilis* (Blind or Slow-Worm) is an inhabitant of Great Britain.

ORDER IV.—*Batrachia* or *Amphibia* (Frogs). We have already referred generally to the extension of the animals of this order. The beautiful little animal *Hyla viridis* (green Tree-Frog), is found in all the countries of middle and southern Europe and northern Africa, to the Island of Teneriffe; it occurs also in Japan; it has never been observed in Great Britain, though it is not uncommon in France. Of the Reptiles belonging to Great Britain, the table shows that the greater number, namely, eight species, belong to this order.

[1] See American Journal of Science, 1842-43. No. 46.

ZOOLOGICAL GEOGRAPHY.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF REPTILIA (REPTILES)

BY A.K. JOHNSTON, F.R.G.S.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF OPHIDIA (SERPENTS) ACCORDING TO SCHLEGEL.

PERPENDICULAR DISTRIBUTION OF THE REPTILES

1 TEMPERATE ZONE (EUROPE)
Mont Blanc (Alps)
1 Rana temporaria (Common Frog)
2 Coluber natrix (Ringed Snake)
3 Vipera berus (Common Viper)
4 Triton cristatus (Crested or Warty Newt)
5 Triton viperinus (Newt or the Alps)
6 Vipera chersea
7 Salamandra (Newt)
8 Rana alpina (Frog of the Alps)
9 Lacerta montana (Mountain Lizard)
Pic Nethou (Pyrenees)
10 Rana temporaria (Common Frog)

2 TORRID ZONE (AMERICA)
Mexico
1 Siredon pisciformis (Axolotl)
Andes of Quito
2 Coluber (Aldero)
3 Crocodilus (Crocodiles)
4 Iwa (Iwaa)

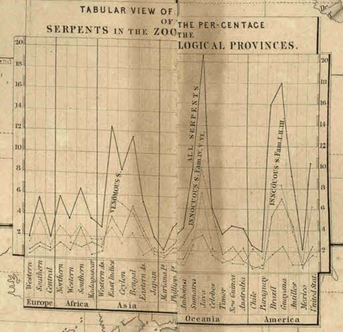
TYPES OF THE REPTILES OF THE NEW WORLD

I. Testudines (Tortoises)
1 Emys (Chelydra) serpentina (Alligator Tortoise)
II. Sauria (Lizards)
2 Tejus monitor (Great Amer. Safeguard or Teguixin)
3 Iguana tuberculata (Smooth-necked Iguana)
III. Ophidia (Serpents)
4 Boa constrictor (Emperor Boa)
5 Crotalus horridus (Common Rattlesnake)
IV. Amphibia (Frogs)
6 Rana virginea (Bull-Frog)
7 Hyla bicolor (Bicoloured Tree-Frog)
8 Pipa Americana (Surinam Toad)
Scale 1/20 of Nature

INNOCUOUS SERPENTS.
Fam. I. Burrowing Serpents
T. ——— Genus Tortrix
Fam. II. Vermiform Serpents
C. ——— Calamaria
Fam. III. Terrestrial Serpents
Cer. ——— Cerastes
X. ——— Xenodon
H. ——— Heterodon
I. ——— Ipsodon
Col. ——— Coluber
Her. ——— Herpetodryas
P. ——— Psammophis

VENOMOUS SERPENTS.
Fam. I. Colubriform venomous Serpents
E. ——— Genus Elaps
B. ——— Bungarus
N. ——— Naja
Fam. II. Sea Serpents
H. ——— Hydrophis
Fam. III. Venomous S. properly so called
T. ——— Trigonocephalus
C. ——— Crotalus
V. ——— Vipera.

TABULAR VIEW OF THE PER-CENTAGE OF SERPENTS IN THE ZOOLOGICAL PROVINCES.



INNOCUOUS SERPENTS
Fam. IV. Tree-snakes
Hem. ——— Genus Hemitrophis
Dr. ——— Dryophis
Dip. ——— Dipsas
H. ——— Hemalopsis
Fam. V. Fresh-water Serpents
T. ——— Tropidonotus
H. ——— Hemalopsis
Fam. VI. Boaform Serpents
B. ——— Boa
P. ——— Python
A. ——— Acrochordus

TYPES OF THE REPTILES OF THE OLD WORLD

I. Testudines (Tortoises)
1 Chelonia imbricata (Bawk's-bill Tortoise)
II. Sauria (Lizards)
2 Crocodilus vulgaris (Common Crocodile)
3 Ascalabotes vittatus (Banded Gecko)
4 Chamaleo vulgaris (Common Chameleon)
5 Tachydromus sex-lineatus (Six-lined L.)
6 Chlamydosaurus Kingii (Frilled Lizard)
7 Lacerta agilis (Sand Lizard)
III. Ophidia (Serpents)
8 Naja tripudians (Common Indian Naja)
9 Vipera berus (Common Viper)
10 - acanthophis (Horned Acanthophis)
IV. Amphibia (Frogs)
11 Bufo cinereus (Common Natter-Jack)
Scale 1/20 of Nature

EXPLANATION

In this Map the intensity of Species is indicated by shading on the same principle as in the first Map of Zoological Geography.
The globe is divided into 7 great Zoological Provinces, each containing a synoptical table of the 4 orders of Reptiles with the number of their species; the total amount with the proportion of all Reptiles being given below.
The principal districts of the Turtle fishery coloured thus. ▭
The colours of the different districts correspond with those in the table, page 1 of the text.

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A.K. Johnston.

SECTION II.

GEOGRAPHICAL DIVISION AND DISTRIBUTION OF OPHIDIA *(SERPENTS)* ACCORDING TO SCHLEGEL.

GENERAL REMARKS ON DISTRIBUTION.—The geographical distribution of Serpents is subject to nearly the same laws as that of other Reptiles; their number increases toward the torrid zone, while comparatively few are found in cold regions. They do not appear to advance so far northwards as Lizards, and Batrachians, which are probably among the number of the most widely distributed Reptiles.

One of the most curious facts in the distribution of Serpents, viewed in relation to different parts of the globe, is their total absence in the numerous isles of the Pacific Ocean; a phenomenon the more remarkable, since the neighbouring isles, forming the great Indian Archipelago, belong to those regions of the earth most abounding in Serpents. Another interesting fact is, that the Serpents, and, indeed, all the Reptiles of America, are specifically different from those of the Old World; while, on the other hand, a great many birds and several mammiferous animals of North America, are precisely the same as those of Europe and a great part of Asia. This is the more singular, because many of our Reptiles are found in all the countries of Temperate Asia to Japan, often without presenting the slightest difference. South America produces, in general, different species from North America, although several of them are perfectly identical in these two vast regions. Some species of the first region also inhabit the Antilles, and are found even in the southern countries of the United States, where they occasionally form climatal varieties; other species, common throughout North America, are distributed in Mexico, and are also met with in the Antilles. America in general, especially in its equatorial regions, is nearly as rich in Serpents as the East Indies. It is very different with Australia, which seems to be inhabited by only a small number of Ophidians; forming, with perhaps the exception of some of its northern parts, species peculiar to that vast island. The Serpents of Japan belong, without exception, to peculiar species, which have not yet been observed in any other spot on the globe. The numerous isles of the great Indian Archipelago often contain species entirely similar, and even absolutely identical, with those which occur in Malacca, Bengal, the continent of India, and Ceylon. Sometimes, however, the species in these different places present differences more or less marked, and occasion the establishment of local varieties. Judging from the small number of its productions known to us, the Island of Madagascar appears to have a fauna of its own. Africa is not rich in Ophidians. The southern part of that vast peninsula produces species different from those of Europe and of other parts of the globe; and these same species are often spread over the whole of intertropical Africa, and are found extending even to the northern parts of that continent; but besides a few peculiar species, these last named countries produce several others, which inhabit, at the same time, almost all the countries bordering on the Mediterranean, even to Syria, and consequently a great part of Europe. Most of the European Serpents are spread over a great part of Temperate Asia—a region which appears to produce only a small number of peculiar species.

The geographical distribution of genera, or of families considered as representing the different principal forms, is not a less curious study than that of the species. We see at once that the Venomous Serpents are distributed, with the exception, perhaps, of some Islands, in every country inhabited by Serpents in general. These dangerous Reptiles do not appear to dread cold, for they are often found as far to the north as the innocuous species; but their number is much more limited than that of the latter; for of the two hundred and sixty-five known species of Ophidians only fifty-eight are venomous, so that the proportion of the venomous to the innocuous is nearly as 1 to 4. We shall afterwards find, however, that this proportion is not the same in all the countries of the globe, and that the number of Venomous Serpents, at least that of individuals, appears to be more considerable in barren and sterile countries, where that of the innocuous seems to diminish. Africa and Australia afford examples of this; in the former continent, the species of known Innocuous Serpents are in the ratio of 2 or 3 to 1, whilst nearly the reverse of this occurs in Australia, where, of the ten known species, seven are venomous. The number of individuals is much more limited in Venomous Serpents, which, with the exception of Sea Snakes, live almost always isolated, and never multiply so as to become abundant, except in very favourable circumstances, as in the case of the *Trigonocephalus lanceolatus* in the French Antilles, or the *Vipera ammodytes* in Dalmatia. Venomous Serpents, then, belong generally to the rare class, and are perhaps much more rare than is generally believed; either because the number of individuals is often very limited, or because (thanks to their habits) they more readily escape the observation of mankind.

Except the anomalous species which compose the family of *Tortrix*, there does not exist one genus of Serpent which is at the same time spread over all parts of the globe inhabited by Reptiles; and this curious fact will serve to demonstrate how intimate is the relation which subsists between the organization of beings and the nature of the places they inhabit. The True *Adders* (*Coluber*), for example, which are destined to inhabit woody or marshy countries, covered with abundant vegetation, have not yet been observed in Australia; and are so rare in southern Africa, that only a single species is known; and this differs in several points of structure, from other Colubri, in so far that it approaches to those Serpents that prefer to inhabit desert or sandy countries. We may apply almost the same observations to the genus *Coronella*—Serpents which inhabit marshy plains or heathy furze-coverts, and of which no species is known to exist in Australia, while those of Southern Africa differ from the typical species. The *Tree Serpents* are especially peculiar to equatorial countries; but as they inhabit vast forests or well wooded regions, they are not found in countries where these conditions, necessary to their existence, are not met with. Hence, probably, the reason why these Serpents have not been found in the greater part of Australia, and that Southern Africa supports only a single species of this family, which, too, is anomalous, approaching to the genus *Coluber*. The three genera which compose the family of Tree Serpents, are found both in the Old and the New World; but it must be observed, that the *Dipsas* of America never attain that great size which is remarked in most of the Indian species, and that the *Dryiophis* of the New World form a true geographical division in this, that they have the dentary system, and the muzzle less developed, and that the pupil of the eye is orbicular.

The Fresh-water Serpents which are comprised in the two genera *Tropidonotus* and *Homalopsis*, are abundant in countries rich in lakes, or watered by numerous rivers; hence it is that these animals are common in Asia, in America, and even in Europe; that they are probably not met with at all in Australia; and that they are rare in Africa: for there exists only a single species of *Tropidonotus* in the southern part of that continent, and even it presents an organization wholly anomalous. The Homalopsis even, which are peculiarly Fresh-water Snakes, and essentially aquatic, and which belong to warm countries, have not been observed either in Australia or in Africa, while they abound in both Americas; they even replace the *Tropidonotus* in South America, which has not yet been observed in that vast peninsula.

The geographical distribution of *Boas* presents several facts worthy of notice. They are peculiar to hot climates. The *True Boas* belong exclusively to South America; and they are replaced in the Old World by the *Pythons*. There are in India, however, several Serpents quite analogous to the Boas, but much smaller; of these there exists, in the whole Western Hemisphere, only one representative, in the Island of Cuba. The *Acrochordus* are exclusively limited to the East Indies.

Among Venomous Serpents, only the genus *Viper*, and perhaps some of the genus *Crotalus*, advance northwards to the temperate and cold regions; whilst the other genera appear to be specially destined to inhabit intertropical countries. Of the Colubriform Venomous Serpents, the genus *Elaps* alone is found both in the Old and the New World; yet the Elaps of America forms a small geographical group, distinguished by the system of colouring, and by some minor details of form. Those of India are striped longitudinally, instead of being annulated with red and black; those of Australia may be considered as forming anomalous species. The *Bungari* are peculiar to the East Indies, where also the *Nejas* are found, although the latter appear to prefer arid or sandy plains—which explains their predominance in Africa and Australia. We are not yet enabled to explain the phenomenon that *Sea Serpents* are exclusively found in the Indian Seas, from the coast of Malabar to the Pacific Ocean. Lastly, it remains to add some curious observations on *Venomous Serpents, properly so called*. Of the three genera of which this family is composed, the *Vipera* is peculiar to the Old World, whilst the *Crotalus* is only found in America, where it replaces the former; but the *Trigonocephalus* is found in both. These last Reptiles, which inhabit wooded countries and extensive forests, are, on this account, not found in Africa or Australia, where they are replaced by the Vipers; but it must be observed that the Viper of Australia forms an anomalous species, whilst those which inhabit Europe differ equally from the typical species, and approach the Trigonocephalus.

TABLE SHOWING THE DIVISION OF *SERPENTS* IN SCHLEGEL'S ZOOLOGICAL PROVINCES AND REGIONS.

FAMILIES and Groups of SERPENTS, with the Number of their Species.	Zoological Provinces and Regions, indicating the degree of mean latitude in which they are situated.																																		
	Europe.			Africa.				Asia.					Oceania.									America.														
	Western R.	Southern R.	Central R.	Northern Af.	Western Af.	Southern Af.	Abyssinia	Western As.	East Indies	Ceylon.	Bengal.	Eastern As.	Japan.	Moluccas Is.	Philippine Is.	Archipelago.	Sumatra.	Java.	Celebes.	Timor.	New Guinea.	Australia.	Chile.	Paraguay.	Brazil.	Guayanas.	Antilles.	Mexico.	United States.							
	47°	41°	36°	33°	7°	37°	20°	42°	15°	7°	25°	35°	35°	15°	13°	3°	0°	6°	8°	9°	6°	25°	34°	23°	13°	4°	15°	23°	36°						
	Number of the Species.																																		
INNOCUOUS SERPENTS, . . . 207	5	13	4	11	9	10	10	7	19	10	20	8	5	2	6	8	18	47	12	7	9	4	7	4	37	41	22	4	24						
I. BURROWING SERPENTS.																																			
1. Tortrix, ... 7	.	1	.	1	.	.	.	1	2	1	1	.	.	.	.	.	1	2	2	.	1	1	1	.	.	1	.	.	.							
II. VERMIFORM SERPENTS.																																			
2. Calamaria, ... 18	.	.	.	1	1	.	1	.	12	.	.	.	.	2	.	2	3	1	1	.	1	2	.	2	2	2	.	4							
III. TERRESTRIAL SERPENTS.																																			
3. Coronella, ... 14	.	1	1	1	.	4	.	1	.	1	.	.	.	.	.	.	1	1	.	.	.	.	2	1	3	3	2	1	2						
4. Xenodon, ... 8	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	.	3	2	.	1	1						
5. Heterodon, ... 3	.	.	.	.	.	2	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	1	1	1						
6. Lycodon, ... 13	.	.	.	.	2	.	.	3	1	2	.	.	.	.	.	.	1	2	.	1	1	.	.	.	1	1	.	1	2						
7. Coluber, ... 27	2	8	1	4	.	1	1	2	.	1	1	3	.	.	.	.	1	2	.	1	1	.	1	3	2	1	.	1						
8. Herpetodryas, ... 19	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	3	1	.	.	.	.	4	2	1	.	.	.						
9. Psammophis, ... 8	1	2	.	2	2	1	2	2	.	.	1	.	.	.	.	.	.	1	2	.	.	.	1	6	7	2	.	2						
IV. TREE SNAKES.																																			
10. Dendrophis, ... 10	.	.	.	.	2	1	.	.	2	2	2	2	.	.	1	2	3	3	.	.	1	1	1	.	1	2	2	.	1						
11. Dryiophis, ... 7	.	.	.	.	.	.	.	.	2	1	.	1	.	.	.	.	1	2	.	.	.	.	.	.	1	3	2	1	.						
12. Dipsas, ... 25	.	1	.	1	.	.	2	1	1	1	2	1	.	.	.	.	1	2	7	4	.	.	.	.	1	4	7	1	.						
V. FRESH-WATER SERPENTS.																																			
13. Tropidonotus, ... 19	1	2	2	2	.	1	1	1	3	2	4	2	2	1	3	.	1	6	1	.	1	.	.	.	.	3	2	1	3						
14. Homalopsis, ... 14	.	.	.	.	.	.	.	1	.	.	2	.	.	.	.	.	1	1	5	.	2	1	.	.	.	3	2	1	3						
VI. BOATOIR SERPENTS.																																			
15. Boa, ... 9	.	.	.	.	.	.	1	.	1	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	5	5	3	.	.						
16. Pythen, ... 4	.	.	.	.	1	.	.	.	1	1	1	2	.	.	.	.	2	2	3	.	1	1	.	.	.	.	.	.	.						
17. Acrochordus, ... 2	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	1	2	.	.	1	.	.	.	.	.	.	.	.						
VENOMOUS SERPENTS, ... 58	.	2	1	4	1	8	.	1	15	13	11	6	1	.	3	3	8	9	4	2	3	7	.	1	5	7	2	2	4						
VII. COLUBRIFORM VENOMOUS SERPENTS.																																			
18. Elaps, ... 12	.	.	.	.	.	1	.	.	1	.	.	.	.	.	1	.	2	3	.	.	1	2	.	.	1	3	1	1	1						
19. Bungarus, ... 2	.	.	.	.	.	.	.	.	2	2	.	.	.	.	.	.	2	.	.	.	.	.	.	.	.	.	.	.	.						
20. Naja, ... 10	.	.	.	1	1	4	.	.	2	1	1	.	.	1	.	2	2	.	.	.	.	.	.	.	.	.	.	.	.						
VIII. SEA SERPENTS.																																			
21. Hydrophis, ... 7	.	.	.	.	.	.	.	.	7	7	7	4	.	.	.	3	2	1	3	1	2	2	.	.	.	.	.	.	.						
IX. VENOMOUS SERPENTS, properly so called.																																			
22. Trigonocephalus, ... 13	.	.	.	.	.	.	.	1	1	2	.	.	1	.	1	.	2	2	1	1	.	.	.	1	2	2	1	.	1						
23. Crotalus, ... 4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2	.	1	2						
24. Vipera, ... 16	.	2	1	3	.	3	.	.	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.						
AMOUNT OF THE SPECIES OF ALL SERPENTS, ... 265	5	15	5	15	10	18	10	8	34	23	31	14	6	2	9	11	26	56	16	9	12	11	7	5	42	48	24	6	28						

The foregoing table precludes the necessity for any detailed account of the division and intensity of Serpents in the different countries of the globe. It may be useful, however, to point out some of the more important facts which it exhibits. On examining the column headed Europe, for example, it will be found that in this quarter of the globe many of the genera are entirely wanting—that it supports neither Calamars, nor Heterodons, nor Lycodons; that the True Tree-Snakes are not found there, nor even the Herpetodryas; that there exists in it neither the Homalopsis nor the Boa; that the families of Colubriform Venomous Serpents and Sea Serpents are never met with; and in short, that the true Venomous Snakes have no other representatives than several species of the genus Vipera.

On comparing the other columns, it will be found that the Island of Java contains the greatest number of species in any of the provinces; that in Australia, by far the greater number of species belong to the Venomous Serpents, &c.; and that, as in the case of the Carnivora among Mammalia, the greatest number, and the most destructive species of reptiles are found in tropical countries, where their presence is required to keep in check the excessive productiveness of other animals.

The above is an abridgment of the "Essai sur la Distribution Géographique des Ophidiens" in Schlegel's work,[1] to which we must refer the student of Ophiology. There is an excellent translation of the general portion of Schlegel's Essay, by Professor Traill, Edinburgh, 1843.

PERPENDICULAR DISTRIBUTION OF REPTILES.

TROPICAL PROVINCE.—As shown in the diagram on the map, Crocodiles and Boas are found on the Andes of Quito, at an elevation of 3,000 feet. *Siredon pisciformis* (Axolotl), a native of Mexico, is found at an elevation of at least 8,000 feet. TEMPERATE PROVINCE.—In the Alps, *Rana temporaria* occurs in the vicinity of the snow line; *Rana alpina*, above 4,500 feet; *Triton alpestris*, 5,400 feet; *Vipera berus*, and *Vipera chersea*, 5,200 feet; *Lacerta montana*, 4,500; and *Anguis fragilis* nearly as high as 6,000 feet. In the Pyrenees, *Rana temporaria* ascends to a height of 7,700 feet.

[1] Essai sur la Physiognomie des Serpens, par H. Schlegel &c. La Haye: 1837.

ETHNOGRAPHIC MAP OF EUROPE,

OR THE

DIFFERENT NATIONS OF EUROPE, TRACED ACCORDING TO RACE, LANGUAGE, RELIGION, AND FORM OF GOVERNMENT.

BY

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INTRODUCTORY REMARK.

An Ethnographic Map would be of great use in History and Statistics, *but of* still greater use in the Natural History of Man. Physiology and Comparative Anatomy, upon which Ethnographic studies ought principally to be based, have hitherto been almost entirely neglected as auxiliaries of History. Circumstances have so far favoured the projector of this Map, as to enable him to see the three great varieties of the so-called Caucasian species in Europe, viz., the Celtic, Teutonic, and Sclavonian, in several countries inhabited by them. He has devoted to the subject of the physical differences of these varieties, their origin, contraction, &c., undiminished attention for a great number of years. Yet, as this is the first Ethnographic Map ever published, based upon the principle of the natural physical difference of the different varieties of the Caucasian species inhabiting Europe, he is fully aware, that it must in many respects still remain deficient, and far below the standard, which he himself would set up for such an undertaking. But a beginning must be made, and in this matter, as in many others, it requires the co-operation of a great number of minds, and a long series of observations by each, to be able to arrive at complete scientific correctness; at which stage such studies may turn out to be highly useful in many more points than can at present be anticipated.

A.—General facts relative to the physical character of nations.

I. The physiological character of a nation lasts longer than its language.

Proof.—The Normans in France, the Lombards in Upper Italy, the inhabitants of the Butt of the Isle of Lewis (one of the Western Islands of Scotland), the inhabitants of several districts of the Scottish Highlands and of N. Wales, several parts of Modern Greece, the inhabitants of the latter of which are undoubtedly of Sclavonian origin, and yet speak Greek, the so-called White Cabyles in the Atlas, who speak an Arabian dialect, although they are a remnant of the Vandals.

II. The same physiological character in two tribes or nations is an indubitable proof of the same origin.

Proof.—Self-evident, and corroborated by historical accounts of settlements in different countries of Europe. Thus, in several parts of Scotland, you find still the Germans of the N. West of Germany, the Norwegians, &c., and in parts of England, the Norwegians, Danes, and Saxons of old; and in Normandy the Norwegians of old,—although the languages spoken in the different countries mentioned vary more to a great extent.

III. Similarity of language in two or more tribes or nations, induces only a supposition in favour of the same origin.

Proof.—Every body would, without a knowledge of the physical character of several tribes or clusters of inhabitants in Scotland, Greece, France, &c., suppose they were of the same origin with their neighbours, from their speaking the same language, whilst the fact is, that they have only assumed this language in course of time, according to what seems to be a natural law, namely, that the language of superior development prevails over that of inferior culture, if the numbers of the conquerors are at all in sufficient proportion to that of the conquered nation. This is exemplified by the Teutonic tribes, who conquered Britain, and colonized (in the 12th and 13th centuries) the N. of Germany, then possessed by Sclavonian tribes; by the Romans in France, Spain, and Portugal; whilst, on the other hand, the Teutonic tribes who invaded Italy, France, and Spain, lost their language, for the reason assigned.

IV. Even in the so-called Caucasian species of the genus Man, there are to be found two distinct shades of complexion, the fair one (Xanthous), and the sallow or darker one (Melanous), each connected with constitutional peculiarities of frame, temperament, &c.

Proof.—The Celtic variety, which is dark (Melanous), whilst the Teutonic is fair. The Sclavonian is in many tribes intermediate between the two.

V. In the crossing of these two shades, the darker one generally prevails over the fairer one in complexion, colour of eyes and hair; the fairer one generally predominates, on the other hand, over the darker one, so far as frame of body, and frequently so far as temperament, are concerned.

Proof.—The Lombards, Castilians, Catalonians, Arragonians, inhabitants of the Franche-Comté, and of N. Germany. In the former the complexion is dark, but the frame of the body is still Teutonic; in the latter (N. Germans) the frame is often a mixture of the Sclavonian and German, but the darker complexion in the mixture commonly prevails.

Note.—The preceding proposition refers to countries in which the crossing of the Melanous with the Xanthous tribes took place on a larger scale, and is very well aware, how many individuals an almost indefinite variety of cross-breeds may be pointed out. To state what proportions of different blood entered into the mixtures which produced the results above alluded to, is almost impossible at the present day.

VI. Increasing civilization exercises a striking influence on colour (not by the crossing of shades alone), and has an evident tendency towards making the darker shade more general.

Proof.—The inhabitants of the country in several parts of Germany, in which it is impossible to prove that a mixture of blood ever took place on a larger scale, when contrasted with those of the towns (the inhabitants of the towns being darker); and in certain larger towns, especially, *e. g.*, Hamburg, Hanover, Brunswick, Cassel, Frankfurt, not to speak of such as Berlin, Vienna, Munich, Stuttgardt, Mainz, Cöln, in which there is evidently a great mixture of blood.

VII. The Teutonic variety has everywhere conquered and trampled under foot, nay, exterminated the other varieties or species, with which it has met in its advance towards the West.

Proof.—The Celtic tribes in the whole West and South of Europe—the tribes of the American species, with which the Teutonic variety in the different British subvarieties came into contact—the conquest of India—colonization of the South-Sea Islands.

This Teutonic variety is undoubtedly the most vigorous and able, both in body and mind, of all the varieties of all species of the genus Man that exist, and seems destined to conquer and civilize the whole world.

VIII. The different species and varieties have an instinctive consciousness of their natural physical difference, which may, to a certain extent, be overcome by a great degree of mental culture, but which, in primitive conditions, is expressed by a mutual aversion and disinclination for intermarriage. This peculiarity has often been denied by well-meaning but one-sided and abstract-thinking philanthropists; but the whole history of all races shows it intimately to exist.

IX. Climate exercises a considerable influence upon the different varieties inhabiting Europe.

The Teutonic variety, in its different subvarieties, agrees best with a temperate climate; it is, however, capable of bearing a high degree of cold; so is the Sclavonian variety. Both seem to prosper best northwards of 45° of northern latitude. Wherever the Teutonic and Sclavonian varieties have settled further southwards, as was the case with the former in Spain and Italy, they have lost, to a great extent, their natural vigour, unless the tertiary in which they lived was considerably elevated above the sea, as is the case with some remnants of the Goths in the Pyrenees, and the White Cabyles in the Atlas. The same may be said of the Sclavonian tribes settled in parts of Turkey, Greece, and the south of Russia. But too great a stress must not be laid upon this point, as, in almost all these instances, the Teutonic and Sclavonian tribes became mixed with the different subvarieties of the Celtic variety; by which mixture their natural physical character was partly changed. The Celtic variety, on the other hand, seems to agree best with the climate south of 45, northern latitude. Its scattered remnants, further northwards, where they are unmixed, as in Brittany, and some parts of the Highlands of Scotland, in Ireland, and Wales, seem not to prosper so well. The astonishing increase of population in Ireland does not contradict this, as, in Ireland, there is more of Teutonic blood than is generally suspected or admitted (not to mention the peculiar moral causes which have brought about this result). How much climate influences the habits and modes of living of different races, or of different tribes of the same race—how much, at the same time, through the agency of the atmosphere, the mind of human beings is affected, may be learned from Liebig's Animal Chemistry.

X. It is natural to suppose, that the stream of immigration went first up the rivers, filling first the plains, and afterwards extending to the mountains.

XI. Mountains, more frequently than rivers, are the natural boundaries of nations.

XII. Mountaineers have been far less affected by the influence of the so-called migration of nations, than the inhabitants of the plains; therefore, we find among the mountineers the remnants of the oldest races in Europe.

B.—General facts relative to the intellectual and moral character of nations.

I. Most subject to change are,—*Forms of government*, next *religion*, then *language*.

Proof.—History of the different varieties of the Caucasian species for the last 3000 years. The Celtic variety in its different subvarieties, during this period, has passed through the different stages of political development pointed out by patriarchal despotic power, aristocracy and democracy—both, however, only to a certain extent, attained in Rome—despotic monarchy, feudal monarchy, imposed upon them, by the Teutonic tribes; and lastly, representative monarchy, without feudal character. They, from being Polytheists, have become Christians, but, without exception, have remained adherents to that Christian Church which, in admitting saint-worship, partakes still, among the uneducated at least, of the character of Polytheism. The language of all the Celtic tribes in Italy, Spain, Portugal, and France, has been *Latinized or Romanized*.

The *Teutonic* variety has undergone several changes in the form of its government, passing from aristo-democratism to feudalism, with representative character; afterwards more or less to absolute despotic monarchy; and lastly, to a superior system of representation, either in the representative monarchy or representative democracy or aristocracy. It has changed from Polytheism to Christianity, and in all its pure branches, in course of time, adhered to the more strictly monotheistic divisions of the Christian Churches (Protestantism). The language has undergone no other change but that of gradual development.

The *Sclavonian* variety has passed from patriarchal and democratic beginnings, through aristocracy, to absolute despotic monarchy—a stage of development at which they are at the present day. From Polytheism its different subvarieties have turned to Christianity, which all of them confess in a form more favouring the primitive polytheistical dispositions of the people. Language has only undergone with them a very slow development.

II. *Least subject* to change are—The *moral sentiments*, next *habits*, and then *intellectual faculties*.

Proof.—History. The French and the Germans have still the same general character which was ascribed to them by the Romans 1800 years ago. The development of the intellectual faculties in a nation depends upon a combination of many apparently accidental circumstances, and may be very high at one time and rather low at another. I have only to refer to the Greeks of old, and to the state that country is in at the present day; to the high state of civilization among the Arabs in Spain in the middle ages, and to the comparative low stage they occupy now; to the Bohemians of the 15th century, and to those of the present day; to the English of the times of Henry VIII., and to the industrious, active race they are at present. But upon examining closely, we will always find, that the ultimate development attained was in exact proportion to the natural talents of the nation in question, and the circumstances which brought them into play; so that there is necessity rather than accident exhibited in the general results of the life of a nation.

C.—Varieties of the so-called Caucasian species of the genus Man, which formerly inhabited, and which still inhabit Europe, in the order of historical succession.

I. *Cyclopean variety. Physiological character unknown.* Inhabited formerly the islands and shores of the Mediterranean. Of its existence there are, besides fabulous accounts, no other proofs than the gigantic structures to be met with in parts of Greece, Italy, the Islands of Malta and Gozzo, &c., which are known under the name of Cyclopean walls, towers, treasure-houses, &c.

Note.—It can only be supposed, but not assumed as certain, that the tribes of which we find traces left in the stupendous monuments alluded to, belonged to the Caucasian species.

II. *Celtic variety. Physiological character;**—Dark (sallow) complexion, dark brown eyes and black hair, with a disposition to turn grey at an early age, and to fall out (bald head), commonly not curled, middle size, slender make, legs curved somewhat inwards, as in females, narrow chest, narrow hips, face and upper part of the skull the exact form of an oval, breis and ankles slender, feet small.

Temperament: bilious and bilious-nervous prevailing.

Intellectual and Moral character. Quickness of perception, great powers of combination and application, disposition for concentrating power; love of equality, of society, of amusement, of glory; want of caution and providence, prevalent disposition for sexual intercourse, gallantry, want of respect for human life. Want of penetration, of desire for personal independence and political and civil liberty; national pride. Disposition to superstition and hierarchy. Foundling hospitals. In most Celtic countries no law regarding paternity, or for the sustenance of so-called natural children by the father. Fine blandishing manners, great external politeness, without inward sympathy. Irascible, not forgetful of injuries, little disposition for hard work. Bad seamen, and not fit for colonizing.

* *Note.*—Unfortunately there is still a want of observation regarding the exact form of the skull, the breadth of chest between the two shoulders, the length of the chest and abdomen, that of the arms and legs, the breadth of the hips, the height of the body by measurement, as also of the weight, the muscular strength, &c. When these measurements and observations shall have been made with due accuracy (as we may expect from a work of M. Quetelet, "On the Proportions of the Human Body," in the composition of which the learned author has already been engaged for a number of years), we will be able to define very simply the physiological character of a nation, or a variety of the human species, by technical terms and ciphers—a method which would also enable us to get a correct standard by which at once to measure any individual, and require coloured engravings to bring out those distinctions to the eye." The author hops to remind those who may object to the denomination of Celtic, given to all the tribes enumerated below, that he bases his definitions merely upon physiological grounds, and does not care whether the name of Celtic was formerly given only to some particular tribes of the whole physiological family of nations, which he has denominated so. By reducing definitions to a *natural* standard, we get rid of the endless confusion produced by Roman, and even by Greek writers, in Ethnography.

(However was this

ETHNOGRAPHIC MAP OF EUROPE

according to

DR GUSTAF KOMBST

F.R.N.S.C.,M.H.S.P.S., &c.

BY A.K.JOHNSTON,F.R.G.S.

Reference to the Colours.

- Teutonic-Pure (Scandinavian)
- Teutonic-Pure (German)
- German-Sclavonian
- German-Celtic
- Scandinavian-Celtic
- German-Scandinavian-Celtic
- Celtic (Gaelic-Welsh-Cornish-Erse-Breton)
- Celtic (Gallic-Roman-Teutonic)
- Celtic (Baltic-Celtic-Grecian-Rom-Teuton-Moor.)
- Celtic (Ibero-Celtic-Roman-Teuton-Moorish)
- North West Sclavonian Pure
- North West Sclavonian mixed
- South East Sclavonian
- Finnish
- Magyar
- Turkish
- Celtic-Pelasgic-Teutonic-Sclav.
- Celtic-Sclavonian
- Tartar
- Tatar-Kalmyk
- Tatar-Kalmyk-Tartar
- Lettic

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A.K. Johnston.

human animals, but also greater energy and versatility of mind to be found; *e.g.*, ancient Greece, Italy in the middle ages, France, Belgium, and Great Britain. On the other hand, it is a well-known fact, that continual intermarrying between certain families at last deteriorates the race.

Proof.—Many of the sovereign families of Europe, which are conspicuous for their bodily and mental infirmities, and many families of the high nobility on the continent, of which not a few, in consequence of mistaken notions of purity of blood, have died out during the last 200 or 300 years. The British aristocracy, which is the only one in Europe among which the notions of purity of blood were never strictly adhered to, is, at the same time, distinguished for the number of fine men and women it can exhibit.

II. Nations, in course of time, lose in vitality and productivity, so far as the continuation of the species is concerned. This is evidently the case with the *Celtic* subvariety, which, if we can believe the ancient authors, was formerly far more numerous than at present; whilst, according to a general supposition, they should have increased at a similar ratio with the Teutonic race, for instance, which, on the whole, has been subject, for the last 2000 years, very much to the same external influences. Yet, at the present day, the Teutonic race (including the United States of North America, and the British Colonies) outnumbers considerably the Celtic, although its numbers were, about 2000 years ago, far inferior to the other.

III. It seems a provision of Providence to have formed different races, to bring about, by their crossing, an improved state of things. It is the object of Ethnographic studies to trace the peculiarities of these different races, and their bearing upon each other; but these studies have nothing to do with theories about the origin of mankind, as little as geology has with cosmogenic theories.

Proof.—History.

I. *Pure blood.*

a. *Teutonic*, in the countries above mentioned, about	- - - -	52,000,000
b. *Sclavonian*, in the countries above mentioned about	- - - -	50,000,000
c. *Celtic*, in parts of Ireland, Scotland, England, France, Grisons, and the Western (French-speaking) Cantons of Switzerland, about	- -	12,000,000
d. *Jews*	- - - - - -	2,000,000
e. *Finnish and Samojedian*, in the countries above mentioned, about	- -	3,000,000
f. *Magyar*, in the country above mentioned, about	- - -	9,000,000
g. *Tatar*, in the south and south-eastern provinces of Russia	- - -	2,000,000
Total of *pure blood*, about		130,000,000

II. *Mixed blood.*

a. *Teutonic-Celtic*, the Teutonic prevailing, in Great Britain and part of Ireland, about	22,000,000
b. *Teutonic-Sclavonian*, the Teutonic prevailing, in parts of Pomerania, Mecklenburg, Prussia Proper, Silesia, Bohemia, Illyria, Carinthia, Salzburg, Carniola, about	6,000,000
c. *Teutonic*, pure and mixed with Walloons, in Belgium, about - -	1,200,000
d. *Teutonic-Northmen* in Normandy, and Teutonic-Alemannic and Franconian in Lorraine, and Burgundian in Franche Comté, about - - -	1,500,000
e. *Celtic*, in its different varieties and crossed, as mentioned above, in France, Spain, Portugal, Italy, and Switzerland, about - - - -	56,000,000
f. *Sclavonian*, prevailing in Germany, Bohemia, Wallachia, about - -	6,000,000
g. *Lettons* - - - - - - - -	2,000,000
h. *Turks* - - - - - - - -	4,000,000
i. *Turko-Tatar-Sclavonian*, from the centre of European Russia, south-east and eastwards - - - - - - -	2,600,000
j. *Kalmyk*, between the Volga and Ural - - - -	300,000
Total of *mixed blood*, about	101,600,000

III. *Summary.*

Total of *Teutonic blood*, pure and mixed, about - - - -	82,700,000
„ *Celtic blood* - - - - - - - -	68,600,000
„ *Jews* - - - - - - - -	2,000,000
„ *Sclavonian blood* - - - - - - -	58,000,000
„ *Letton* - - - - - - - -	2,000,000
„ *Finnish and Samojedian* - - - - - -	3,000,000
„ *Turks* - - - - - - - -	4,000,000
„ *Magyar* - - - - - - - -	9,000,000
„ *Tatar*, - - - - - - - -	4,600,000
„ *Kalmyk* - - - - - - - -	300,000
Total of the population of Europe, including 800,000 Gypsies - -	231,600,000

Note.—Mention should be made of the circumstance, that the Teutonic population out of Europe (United States of N. America, and the British Colonies), amounts to about 20,000,000, so that the total of Teutonic blood would be rather more than 100,000,000.

E.—Distribution and classification of the different varieties of the Caucasian and Mongolian species, in their pure and mixed state, according to the localities which they inhabit.

I. *Teutonic.*	Scandinavian.	Northman.	Iceland, Faröe, Shetland, Orkney Islands, Norway.	
		Gothic.	Sweden and the adjacent Islands.	
		Danish-Illian.	Denmark and the adjacent Islands.	
		Saxon.	Hanover, Brunswick, Westphalia, parts of Saxony, Holstein, Mecklenburg, Pomerania, Anhalt, Transylvania.	
		Batavian.	North Holland.	
		Frisian.	Coasts of the North Sea, both sides of the Elbe and Weser, Holland, Swiss Cantons of Schwyz, Uri, Unterwalden, (!) upper part of Valais.	
a. *Pure.*	German.	Thuringian.	Parts of Saxony, Saxon Duchies, Principalities of Anhalt.	
		Hassian.	Hesse, Middle Rhine, Thuringia.	
		Francconian.	Northern part of Bavaria, Middle Rhine, Hesse-Darmstadt, Rhenish Bavaria.	
		Alemannic.	Part of Bavaria (Western), Würtemberg, Grand Duchy of Baden, Alsace, Northern Cantons of Switzerland, Black Forest.	
		Suabian.	Western part of Bavaria, Würtemberg, Black Forest.	
		Northman-Scottish.	North and Eastern Coast of Scotland.	
		Northman-English.	Northumberland and Durham.	
		Northman-Irish.	North Coast, and part of the South of Ireland.	
		Danish-Scottish.	Part of the Eastern Coast of Scotland.	
b, Mixed.	Scandinavian.	Danish-English.	Durham, Northumberland, Essex, Sussex.	
		Danish-Irish.	Southern and Western Shores of Ireland.	
		Norman-English.	Majority of English Counties.	
		Norman-Irish.	East of Ireland.	
		Northman-French.	Normandy.	
		Northman-Neapolitan & Sicilian.	Coasts of Naples and Sicily.	
		Saxon-British Celtic.	Lowlands and S. of Scotland, N. W. of England, Cumberland.	
		English-Irish.	Eastern Coast of Ireland.	
		Flamish-German.	Flamish part of Belgium.	
		Alemannic-Celtic.	Würtemberg, Grand Duchy of Baden, Alsace.	
		Suabian-Celtic.	Northern Cantons of Switzerland.	
		Alemannic-Celtic-Sclavonian.	South and East of Bavaria, Austria.	
		Maroccannian-Celtic-Sclavonian	Lorraine.	
		Francconian-Lotharingian.	Lombardy.	
b, Mixed.	German.	Longobardian-Celtic.	Catalonia.	
		Gothic-Celtic.	Castilia.	
		Vandalian-Celtic.	Arragonia.	
		Burgundian-Gallic-Celtic.	Burgundy (Franche Comté).	
		Saxon-Sclavonian.	Pomerania.	
		Thuringian-Sclavonian.	Mecklenburg.	
			Brandenburg.	
			Silesia, Prussia Proper.	
		Francconian-Sclavonian.	Fulda and Fichtelgebirge.	
		Teutonic-Pelasgo-Celtic.	Ancient Greece.	
II. *Celtic.*	Gaelic.		Western Coast and Highlands of Scotland.	
	Erse.		Interior and Western, and greater part of Southern Coast of Ireland.	
	Cymrian Welsh.		South and part of North Wales.	
a, Pure.	Cornish.		Cornwall.	
	Manx.		Isle of Man.	
	Breton.		Little Brittany.	
	Basque.		South-eastern part of France, Basque Provinces of Spain.	
	Grison.		Grisons in Switzerland.	
b, Mixed.	Auvergnat.		Auvergne in France.	
	Flamand-Walloon.		Southern part of Belgium.	
	Cornish-English.		Cornwall.	
Note.—The name of that subvariety is in constantly grows less, which prevails in the branches.	Gallic-Roman-Teutonic.		Most Provinces of France, those above-mentioned excepted.	
	Ibero-Celtic-Roman-Teutonic-Moorish.		Spain and Portugal.	
	Italic-Celtic-Grecian-Roman-Teutonic-Moorish.		Italy, Sicily.	
	Pelasgo-Grecian-Teutonic-Sclavonian-Turkish.		Greece and the Grecian Islands.	
III. *Sclavonian.*	Polish.		Poland, Grand Duchy of Posen, Gallicia.	
	Wendian.		Lusatia, Thuringia.	
	Serbian.		Eastern Borders of Pomerania.	
	Cassubian.		Bohemia.	
	Czechian.		Bosnia (Great and Little).	
	Russian (Great and Little).		North-west of Hungary.	
	Bassiako.		Moravia.	
	Moravian.		Sclavonian parts of Hungary.	
a, Pure.	Sclavonian Proper.	Sclavonian.	Croatian parts of Hungary.	
	Croatian.		Montenegro.	
	Montenegrine.		Servia.	
	Servian.		Bosnia.	Turkey.
	Bosnian.		Morlachia.	
	Morlachian.		Bulgaria.	
	Bulgarian.		Epirus, Thessaly.	
	Arnauto.		Part of Styria, Carniola, Carinthia.	
	Sulioto.			

b, Mixed.	Serbian-Saxon.		Lusatia, part of Thuringia.
	Czechian-Francconian.		North-western part of Bohemia.
	Czechian-Saxon.		
	Wallachian-Russian.		Moldavia and Wallachia.
	Illyrian.		Illyria.
	Talmatian. Celtic.		Dalmatia.
	Sclavonian.		Confines of Switzerland, Tyrol, and Germany.
	Lithuanian-Finnian.		Lithuania, Livonia, Curonia.
IV. *Finnian* variety of the Mongolian species.			
a. 1, Pure.	Finnian Proper.		Northern parts of Norway and Sweden.
	Samojedian.		North-eastern parts of Russia.
b, 1, Mixed.	Finnian-Northman.		Coasts of the White Sea, and of the Grand Principality of Finland.
	Finnian-Gothic.		
	Finnian-Sclavonian.		North-eastern parts of Russia.
	Finnian-German.		Curonia, Livonia, Esthonia.
a, 2. Pure.	Magyar.		Hungary.
b, 2. Mixed.	Magyar-Sclavonian.		Hungary, Transylvania, Gallicia.
	Lithuanian.		
Letton.	Letton.		Lithuania, Livonia, Curonia.
	Curonian.		
V. Turks.	Turkey.		
VI. *Tatar* variety of the Mongolian species.			
Mixed.	Nogaic-Tatar.		Banks of Caban and Don.
	Crimean or Taurian-Tatar		Russian Government of Taurien, Iekaterinslav.
	Cossa-Tatar.		Government of Kasan.
	Mescheherjakian-Tatar.		Government of Orenburg.
	Tatar-Kalmyk-Russian.		Between the Don and Volga Rivers.
VII. *Kalmyk* variety of the Mongolian species.			
	Soongar-Kalmyks.		
	Torgut-Kalmyks.		Prairies between the Volga and Ural rivers.
	Derbet-Kalmyks.		

It is scarcely necessary to add, as a general remark, that, although the character of every variety and subvariety, pure and mixed, can be sufficiently traced and pointed out, yet there is as great a difference in individuals of the same tribe, in consequence of individual cases of crossing, and increasing civilization, as between animals of the same breed. With regard to the latter, more especially those which are of use to man, or serve for his amusement, as horses, dogs, cattle, &c., a great deal of accurate knowledge about the peculiarities of species, varieties, &c., has already long existed, and even peculiar care has been taken to improve individual breeds, whilst, although of infinitely more importance, man has been exceedingly careless, and is, consequently, ignorant of the natural history of his own species.

F.—Languages.

General facts relative to European Languages.

I. All European languages can be traced back to the Sanscrit (the language of the educated classes more especially the priests, among the ancient Hindoos), as an approximate common source, from which their peculiarities receive a proper explanation, and in which a solution is found for every phenomenon, to elucidate which there is no clue in any other language.

II. Language is to a great extent something organic, independent of the will or caprice of man. The changes which the different European languages have undergone in inflection and structure, are greater than the changes which have taken place in the physical and moral character of nations. Not to speak of mixed languages, we have only to look to the pure ones, *e.g.*, the Teutonic ones, for the changes which they have undergone for the last 1500 years—changes which are so great, that it is difficult for the uninitiated to find in the Gothic and Old Saxon the mother of the present German dialects.

III. Palatal and guttural sounds prevail in the language of mountaineers.

IV. Labial sounds prevail in the language of the inhabitants of flat countries, more especially those surrounded by the sea.

V. The vowel system of all languages is less rich (more developed) in the language of the educated classes, than in the dialects spoken by the country people.

VI. There is a law of interchange of consonants relative to all the languages which belong to the same stock. According to this law we may have in one language, in a word which is of the same origin with another of the same meaning in a cognate language, a different consonant, however, belonging to the same class of consonants to which the consonant in question belongs; *e. g.*, English, *ride*, German, *reiten*: *English*, *bride*, German, *braut*; English, *beach*, German, *tod*; English, *daughter*, German, *tochter*; English, *sleep*, German, *schlaf*; English, *break*, German, *brechen*, &c., &c.

VII. The High German and the Icelandic (!) are the only two modern European languages in which the vowels have only one pure distinct sound, whilst in all other languages there are different shades of sound attached to most of them.

VIII. The grammatical construction of sentences, as well as the proper formation of periods, depends, besides logical, also upon rhythmical laws, which are peculiar to the different languages.

IX. These laws undergo some changes in course of time,—partly in consequence of the greate development of the languages, and partly in consequence of the languages becoming mixed.

X. Mixed languages, to a certain extent, lose the power of organic life, and their flexibility.

XI. The less developed a language, the richer are its forms of inflection; the more developed, the poorer.

XII. The languages least developed in the vowel and consonant system among the European languages are the Sclavonian ones; but they are richest in forms of inflection.

XIII. The limits of languages are commonly formed by mountains, as we find in some mountains of the Alps the borders of three languages (German, French, and Italian). Sometimes they are formed by rivers, *e.g.*, in the Canton of Freiburg in Switzerland, in the city of Freiburg itself, where the river Sarine forms the limit between the German and French-speaking populations.

XIV. A language cannot be forced upon a nation, unless it be not only superior to that which it is intended to supersede, but also propagated by a superior number in those who intend to force it upon another nation. This, however, holds only good in rude, barbarous times, and in periods of comparatively high civilization, when both nations are civilized. This is exhibited by the vain attempts of the Romans to introduce their language into Germany; by the French to spread theirs in Alsace; and by the Germans to spread theirs over Bohemia. But there is a strange fact on record, that, 150 years after the North of Germany had been conquered by the Germans, and colonized, there was, from the frontiers of Holstein to the river Rega, in Pomerania, scarcely a person to be found who knew any thing of the Sclavonian language spoken by the former inhabitants of the country. (Compare p. I. III.)

Note.—It is interesting to observe the changes that have taken place in some countries as to the prevailing language. Thus, *e. g.*, in the middle ages, Teutonic dialects were spoken in several parts of Belgium to the sea-coast. The very name of the French sea-port Dünkirchen (Dunequerque) is Teutonic. The same was the case in Switzerland, where the German extended (in the towns at least) so far as Geneva. In the course of the 17th and 18th centuries, however, in Belgium, as well as the western portion of Switzerland, in the towns universally, and in the country generally (in Switzerland at least), the French has become the predominant tongue. But in the latter country it has only extended so far as the Celtic element of the population reaches.

Distribution of Languages over Europe.

I. *Pure.*

a, *Teutonic.*

German. (*Hochdeutsch*, the language of the educated classes in all parts of Germany.)
- a, First Branch: (Mosso-Gothic), *Alemannic, Suabian, Bavarian, Francconian, and Hassian* (*Thuringian*) dialects, spoken respectively in Würtemberg, Baden, Alsace, the German Cantons of Switzerland, Bavaria, Hesse-Darmstadt, Hesse-Cassel, the Tyrol, and the German Provinces of Austria.
- b, Second Branch: That of which the most-ancient dialects known are the *Anglo-Saxon*, the *Old Saxon*, and the *Frisian*, of which their exist at present, the *Plattdeutsch*, the *Frisian*, the *Dutch*, the *Flamandish*, and the *Broad Scotch*. Spoken respectively in N. Germany, Holland, part of Belgium, and the Lowlands of Scotland.

Scandinavian.
- c, Third Branch: That of which the most ancient dialect known is called *Norse* (in the Faröe, and to a certain extent in the Shetland and Orkney Islands), of which there at present exist, the *Icelandic*, the *Danish*, the *Norwegian country dialects*, and the *Swedish*, spoken in the respective countries of which they bear the name.

b, *Sclavonian*, comprising the following branches, with numerous subdivisions:—
- a, Russian.
- b, Polish.
- c, Czechian or Bohemian.
- d, Cassubian.
- e, Sorbian.
- f, Servian.
- g, Moldavian.
- h, Montenegrine.
- i, Arnauto, spoken in the countries of which they bear the name

c, *Celtic*. 1, *Gaelic*, spoken in the Highlands of Scotland; 2, *Erse*, by the country people and lower classes in most parts of Ireland; 3, *Kymric* or *Welsh*, spoken by the lower classes in Wales; 4, the *Manx* (nearly extinct), spoken in some parts of the Isle of Man; 5, *Breton*, spoken in Little Brittany; 6, *Basque* spoken in the south-west corner of France, by the country people, and in the Basque Provinces of Spain.

The following tables are taken, the first from the valuable work of Henry Marshall, F.R.S.E., Deputy Inspector-General of Army Hospitals, "On the Enlisting, Discharging, and Pensioning of Soldiers," and the others from the Edinburgh Medical and Surgical Journal, vol. xiii.,—

TABLE showing the Average Circumference of the Chests of the Recruits examined in the London District, from the 13th October 1838, to the 12th January 1839, inclusive, arranged according to the Height of the Recruits.

Height of the Recruits.	Town Recruits.			Country Recruits.			Aggregate.		
	No. exa-mined.	Average size of chest.	No. found fit.	Average size of chest.	No. exa-mined.	Average size of chest.	No. found fit.	Average size of chest.	Average size of chest.
Ft. In. to Ft. In.		In. Dec.		In. Dec.		In. Dec.		In. Dec.	In. Dec.
5 5 to 5 6	83	32.44	53	32.54	23	32.77	20	32.68	32.57
5 6 to 5 7	425	32.63	279	32.79	233	32.74	157	32.86	32.75
5 7 to 5 8	223	32.24	127	32.53	103	33.11	93	33.18	32.82
5 8 to 5 9	122	32.27	74	32.81	56	33.09	47	33.18	32.93
5 9 to 5 10	58	32.76	33	32.95	28	33.75	23	33.57	33.00
5 10 to 5 11	44	32.54	27	32.84	13	33.61	9	33.81	33.14
5 11 to 6 0	20	32.90	10	33.00	3	33.67	2	33.80	33.23
And upwards,	4	32.88		32.00	1	35.00	1	33.00	33.50
	979	32.60	603	32.72	460	32.91	394	32.99	1439	32.47	1060	32.66

Comparative Statement of the Height and Thickness of Men round the Chest, in different Countries.

Comparative Sizes of Men's Heads, as ascertained by actual Measurement upon an extensive scale, in Retail Hat-shops in London and Edinburgh.

Average Heights of Men.

Regiments.	Average Inches round the chest.	Average inches in height.
Highland Lancers,	38.71	67.39
2d Edinburgh, .	38.79	68.04
Kinross, . .	39.07	67.39
Peebles, . .	39.55	68.38
2d Fife, . .	39.52	67.29
6th Lanark, . .	39.31	68.08
2d Argyll, . .	40.07	67.74
1st Argyll, . .	40.09	67.76
East Stirling, . .	40.00	68.06
Annan and Eskdale,	40.64	68.15
Kirkcudbright, .	41.01	68.59

Heights.	Number of the different sizes in 100.	Inches cir-cumference.	Edinburgh, No. in 100.	London, No. in 100.
Ft. In. to Ft. In.				
5 4 and 5 5	15.2	19.5	0.000	.450
5 6 " 5 7	37.2	20.078	0.285	.164
5 8 " 5 9	31.2	20.25	2.285	4.942
5 10 " 5 11	13.5	20.625	6.285	11.491
6 0 " 6 1	2.9	21.	12.428	25.854
		21.375	27.428	28.850
		21.75	21.571	15.344
		21.125	13.000	10.049
		22.5	8.428	3.289
		22.875	3.142	0.328
		23.25	0.857	0.328
		23.625	0.285	0.164
		24.	0.000	0.000

The above tables contain the only information the author has been able to collect on the subject in question; but entirely insufficient, as to the point of race, and incomplete, as it is, he lays it before the public, to induce others to continue collecting facts, and thereby complete those results.

The Celtic variety comprises the following subvarieties :—

1. *Iberian* subvariety, constituting, so far as we know, the primitive population of Spain and Portugal, and the Balearian Islands, which afterwards became blended with Carthaginians, Romans, Goths, Vandals, Moors. There is only a remnant of it to be found unmixed in the Basque Provinces of Spain,* and in the south-western parts of France, on the Spanish frontiers. Although this subvariety, according to all probability, preceded the other Celtic subvarieties in Europe, it is not in the ancient remains to consider it as a distinct variety of the Caucasian species, as is often done; on the contrary, its physiological character renders it necessary that it should be subsumed under the Celtic variety.

* *Note.*—Recent travellers have frequently made mention of the inhabitants of *some* of the valleys in the Basque Provinces, in a manner that should make one suppose them to be remnants of the *Vandals and Goths*, who went to Spain. For the present, however, on account of an accurate description of their physiological characteristics being still wanting, this point must be left undecided.

2. *Italic-Tuscan-Ocsian-Sicilian* subvariety, formed by the ancient inhabitants, so far as we know, of Italy, and Sicily, Sardinia, Corsica, and the neighbouring islands on the western coast of Italy. It afterwards blended with Pelasgo-Grecians and Grecian immigrants, who filled the south of Italy, and part of Sicily. This subvariety attained the highest development in the *Roman* race, which, after having crossed Spain, Portugal, France, and parts of Britain, was crossed in its turn by the Vandals, Goths, Longobards, Northmen, and Arabs.

3. *Pelasgo-Grecian* subvariety, inhabiting, in ancient times, the Peloponnesus, Hellas, and the islands of the Archipelagus, and of the Ionian Sea. It was, at an early period, crossed by Teutonic tribes (the Greeks themselves were nothing but a race mixed of the ancient Celtic inhabitants and Teutonic invaders; the Teutonic character in this mixture being more prevalent in the *Dorie* tribe, the Celtic more in the *Ionian*.)†

† *Note.*—What has been said about the ancient crossing of the Pelasgo-Celtic race by a Teutonic tribe (Herculidian immigration), may appear rather strange and bold. Yet I am not the first to entertain an opinion of the kind, as Dr M'Culloch (Highlands and Western Islands of Scotland, &c., &c., vol. iv., p. 365) and Dr Prichard (Researches into the Physical History of Mankind, vol. iii., p. 327) have both, to a certain extent, ventured upon a similar one. To condense my arguments, I shall address them in a numerical order, as short as possible.

1. Such expressions as ἡελίοιο φαεσίμβροτον, which frequently occur in Homer, in regard to the colour of the hair (this is especially done regarding Menelaus, who has this epithet nearly always prefixed to his name); as γλαυκῶπις (Athéné) (blue-eyed), applied to Minerva, βοῶπις (Hēre) (oxen-eyed, that is, with large eyes), so applied to Juno, and ξανθὸς Μενέλαος (the well-bearded or flaxen-haired Menelaus), as also to the Achæans by Homer, and which, strangely enough, has been translated by philologists, "well provided with armour on the legs,"—stand in direct contradiction to the country where they were at home, and to which the English family names of White, Reid (red), Black, Brown; and the German ones of Weiss, Roth, Schwarz, Braun, &c., and where, in consequence of the opposite peculiarities being perhaps as frequent, they were as generally understood. Homer's epithets, *fair hair, fine eyes, fine complexion*, &c., belong exclusively to the Teutonic variety; consequently there must have been Teutonic blood circulating largely in the veins of the ancient Greeks.

2. Not to mention the language (which is evidently a mixture of *Celtic* and *Teutonic*, the latter prevailing in the inflectional forms, as well as in the roots and in the whole structure), let us compare their manners, customs, dispositions, and general turn of mind, and we shall find the greatest, nay, a surprising similarity between the ancient Greeks and the Teutonic tribes, more especially the German generally. I have only to refer the doubtful reader to Otfried Müller's Dorians, the profession of a scholar, who had no hypothesis, as that which he was to defend. (History and Antiquities of the Doric race, translated from the German by H. Tuffnell and G. C. Lewis, 2 vols., maps.)

3. Skulls found in ancient Greek tumuli, which, compared with those of Teutonic tribes, more especially with the skulls of individuals of Germanic nationality, exhibit the greatest resemblance in every point.

4. An accurate study of Greek statuary, made in different capitals of Europe, especially at Paris, has given me the most evident proof, that the sculptors themselves were aware of a difference of race among the Greeks, so far as exhibited by a different bodily appearance. We find there models of the Celtic and of the Teutonic variety. Hercules, *e.g.*, and Jupiter are every inch of them Teutonic figures. Not to speak of what probably would be called ideal portraits, let us look at real ones, and we shall find that the most distinguished Greek philosophers, poets, orators, statesmen, had Teutonic heads; compare, *e.g.*, those of Socrates, Plato, Demosthenes, Æschines, Euripides, Æschylus, Pericles, Miltiades, Cimon. I have taken friends most unwilling in my theory, physiologists and not physiologists, to examine busts of casts from ancient statuary, and all of them have left those collections surprised at what they saw, if not fully convinced of the correctness of my views on this question.

I could likewise show, that a great deal of Teutonic blood flowed in the veins of the Romans, but this not being the place for such discussions, I must reserve my arguments for another time and more appropriate place.

4. *Gallic* subvariety, inhabiting in ancient times, France (Gaul) and Upper Italy, the Western Cantons of Switzerland (in which French is now spoken), Grisons, and the southern part of Belgium. They were crossed in course of time by the Romans, and the following Teutonic tribes:—the Goths, Burgundians, Franks, and Alemanns.

5. *British and Irish* subvariety, the former again subdivided into the *Welsh* and *Cornish*, the latter into the *Irish* proper, the *Manx*, and the *Gaelic*; inhabiting Great Britain and Ireland; in course of time extensively crossed, and partly exterminated by the Teutonic tribes of the Scandinavian Peninsula, Denmark, Germany, and Normandy.

6. *Arabian-Hebrew-Celtic* subvariety (known under the name of the Jewish), spread over all countries of Europe, more especially Germany, Poland, and Russia.

III. *Teutonic* variety. *Physiological character*:—Fair complexion, fair, often flaxen, reddish, golden-coloured smooth hair, commonly not curled, large blue eyes, ruddy cheeks, broad high brow, skull larger and rounder than in the Celtic variety, bones thicker, chest broader, so the hips, legs straight, head and ankles strong, feet often large, even clumsy, when compared with the Celtic variety, powerful strength of muscle, tallness of figure, above what is called the middle size, skull and face of a form that approaches nearer to a half-circle, to which the thinner end of the oval is added; disposition to become corpulent. Temperament: sanguine and phlegmatic prevailing.

Intellectual and Moral character.—Slowness, but accuracy of perception, general slowness, but depth and penetration of mind, not brilliant for witticism like the Celtic variety, but distinguished by acuteness; want of concentativeness. Fondness of independence, it being valued more highly than equality of condition or rank. Self-government in all spheres of life. Proverbially cautious, reserved, hospitable, but not sociable on a large scale, with aristocratic-conservative tendencies, and fond of titles and social distinctions. Respect for women, without assuming the Celtic character of frivolous flippancy. No foundling hospitals. Spirit for benevolent foundations. Recklessness regarding other nations' rights; overbearing, haughty spirit, leniency; forgetfulness of received injuries. Musical talent in most Teutonic tribes great. Skilful seamen, adventurous, distinguished for cleanliness, on the whole fond of spirituous liquors. (For explanation of the latter peculiarity, see Liebig's Animal Chemistry.) It comprises the following subvarieties:—

1. The *Scandinavian*, inhabiting Iceland, the Faroer, Shetland, and Orkney Islands, Norway, Sweden, Denmark, and the Islands on the Danish, Swedish, and Norwegian coasts.

2. The *German* subvariety, inhabiting Germany, Holland, the German Cantons of Switzerland, part of Schleswig and Transylvania, and forming the populations of the towns in Curonia, Livonia, Esthonia; in which countries also the gentry in the country are of German origin. No Teutonic tribe has ever been crossed by subsequent conquerors; Teutonic tribes mixed, however, in some localities with the vanquished enemies; but this has taken place in the course of centuries only, as, for instance, in N. Germany. There is a mixed *Scandinavian* population, however, with prevalent Teutonic character, in Scotland, parts of England and Ireland; and a mixed *German* in England (Anglo-Saxons), with prevalent Teutonic character, the Celtic element in the mixture being comparatively small; and in parts of Mecklenburg, Pomerania, Brandenburg, Silesia, Prussia Proper, Saxony, Bohemia, Styria, Carinthia, Carniola, with tribes of Sclavonian origin; and in Suabia, the Black Forest, Alsace, and in the Cantons of Basel, Zurich, Argovia, Thurgovia, and St Gall, the German element is probably mixed with the Celtic and Sclavonian.

IV. *Sclavonian* variety. *Physiological character*:—Complexion sallow, between that of the Teutonic and the Celtic races; eyes grey or hazel brown, and often deep in the head; hair dark in its different shades, not smooth, frequently of a bristly character, rarely curled; form of skull and face more square than oval, cheek-bones frequently prominent, brow low, the hair growing far down upon it. Stature stout and broad, neck short and thick, bones strong, limbs straight, ankle, heel, and feet strong, great muscular strength, hardy in constitution. Temperament: phlegmatic, sanguine-bilious prevailing.

Intellectual and Moral character.—Great mechanical talent, talent for imitation, for music; when subjected, cunning, deceitful, and revengeful; when free, frank, open. Although originally democratic in consequence of national misfortunes, a great leaning towards a paternal and despotic authority, liberal obedience, tenacious of old manners and prejudices. Hatred of the Germans (who, for more than a thousand years, have conquered and oppressed them); love of country, without a spirit of adventure; clever and cunning merchants; want of cleanliness; love of lyrical, more especially elegiac poetry and songs.

It comprises the following subvarieties :—

1. The *so-called North-eastern Sclavonians*, consisting of the Poles. Wenden, Sorben, Czechs, occupying Poland, parts of Prussia Proper, the eastern borders of Pomerania, parts of Lusatia, the eastern borders of Silesia, Bohemia, and Moravia.

2. The *South-eastern Sclavonians*, represented by the Russians (Great and Little Russia), Wallachians, Servians, Sclavonians proper, Dalmatians, Croatians, Illyrians, Montenegrians, and Armutes (Greece), inhabiting the countries which bear their respective names.

3. The *Lettons*, intermediate between the Sclavonian and Finnian, but now, more especially in Lithuania, much mixed with Sclavonians, on the banks of the rivers Niemen, and Düna, subdivided into, 1. *Lithuanians*, in the Governments of Wilna, Grodno, Minsk, Volhynia; 2. *Lettons*, in Livonia in the country; 3. *Curons*, in Curonia and Semgallia in the country.

Note.—To Phrenologists it will be interesting to find here also a sketch of the *phrenological character* of the three principal varieties of the Caucasian species inhabiting Europe. This sketch the author owes to the kindness of George Combe, Esq., and he inserts it here in that gentleman's own words :—

"The *Celtic skull* is long from front to back, moderate in breadth, and moderate in height. Among the organs of the *animal propensities*, *philoprogenitiveness*, *adhesiveness*, *concentrativeness*, and *constructiveness* predominate. *Destructiveness* is considerable, but less than *combativeness*. *Self-esteem* is large, and *love of approbation* rather large. The coronal region is generally little elevated above *cautiousness* and *causality*; that is to say, the region of the *moral sentiments* is only moderately developed, but *veneration* is larger than benevolence and conscientiousness. The *intellectual* organs also are only moderately developed. In so far as I have had the means of observing, the different varieties of the Celtic race differ considerably from each other in the intellectual organs. The Scotch and Welsh Celts have the reflective organs as highly developed as the knowing organs, while the French and Irish Celts have the knowing organs much more fully developed than the reflecting. In the Scotch and Welsh Celts *cautiousness* is fully developed, while in the French and Irish Celts it is small when compared with the other organs. *Identity* is deficient in the Celts.

"The Teutonic head is very different. It is very broad, but not long from front to back; the predominating animal organs are *cautiousness*, *destructiveness*, *acquisitiveness*, and sometimes, *Combativeness* and *adhesiveness* are inferior in size to the foregoing; and *philoprogenitiveness* is not so generally large as in the Celtic, especially in the male sex. *Conscientiousness* is generally deficient in the Teutonic race. The moral sentiments region, that of the moral sentiments, however, is far larger than in the Celtic. The Teutonic race has generally large *benevolence*, *veneration*, *wonder*, *conscientiousness*, and *firmness*, and many individuals have also much *ideality*, although many are deficient. *Love of approbation* is larger than *self-esteem*, although both are considerable. The Teutonic intellectual organs are much larger than those in the Celtic race; the *forehead* is broader, and hence there is more capacity for music in the Teutonic. The Teutonic intellect has large organs of *comparison* and *causality*, the latter generally larger than the former, which gives a love of abstract and profound thinking; but *individuality* and *eventuality* are generally deficient; the consequence of which is, that the Teutonic race is far fonder of abstractions and speculations, than of the study of actual objects and events, with a view to increase the knowledge of them in practice. It lives in a world of feeling and speculation, much more than in one of accurate observation and practical application. The Teutonic race is distinguished for simplicity of character, benevolence, and honesty, when not perverted, when excited, can command considerable intellectual energy. It is also prudent, for *cautiousness*, as well as *acquisitiveness*, is large. The French and Irish Celts are rash and impetuous. The Teutonic race is deliberate and slow.

"I have not been enough in Germany to be able to describe it. In Bohemia they seemed to me to be like a higher order of Celts, but my progress was too rapid to enable me correctly to observe their heads."

V. The *Turks* are a mixed race of original Tatar (Mongolian) and Caucasian elements, so that they might be ranked among either species; the Caucasian character seems, however, to be prevalent among them at present. In consequence of the very many concurrent elements of this subvariety, it is difficult to assign a correct physical typus to it, which would be applicable to all of them. To a great extent they will partake physically of the character of the Tatar variety of the Mongolian species (see below), being, however, finer made, their limbs in better proportion, the eyes without the oblique Mongul cut, and invariably with fine noses.

Their intellectual and moral character is as difficult to define; they are haughty, cunning, clever, lazy, ferocious.

They inhabit part of the Turkish Empire in Europe (Thrace, Theassly, Macedonia.)

VI. The *Finnian* variety of the *Mongolian* species of the genus Man, comprising the following subvarieties :—

1. The *Finnians* proper, consisting of the Lappoons, Quänians, Finnians, Esthonians, in the respective countries which bear their name; Permians (Government of Perm); Woguls, on both sides of the Ural in the Government of Perm; Tscheremesses, on the left bank of the middle part of the river Volga; Tschuwasches, on the banks of the middle division of the river Volga; Mordwines, on the banks of the Oka and Volga in the Government of Nijni and Kazan.

Physiological character.—Skull and face somewhat square, face flat, cheeks receding, dark-grey eyes, small, dark, often deep-set eyes, dark, sometimes fair, coarse hair, stature middle size, muscular strength middling, great durability of body. Temperament: phlegmatic-bilious prevailing.

Intellectual and Moral character.—Grave, energetic, hardy, bold, pertinacious, hospitable, but in an extraordinary degree obstinate.

2. The *Samojedic* subvariety, in the N. eastern part of European Russia, on the shores of the White Sea. *Physiological character*:—General character the same as the preceding, with the peculiarity of broad and flat noses, eyes small, dark brown or black, lying deep in the head, and in the oblique direction peculiar to the Mongolian species.

3. The *Mongolian* subvariety. *Physiological character*:—Complexion sallow, skin often delicate, so that the sallowness is different from that of the Celtic variety, face short, cheek-bones frequently prominent, skull more round than square, eyes small, dark brown or black, frequently deep in the head, with Mongolian oblique cut, hair black, smooth, neck short, stature middle sized; neither so broad nor so stout as the Sclavonian, but equally robust. There is a great difference in the outward appearance of the higher class (or nobles) and that of the people generally; the former combining, with some of the peculiarities mentioned, as regards the eye and complexion, the fine shape of the face and skull of the various Caucasian races. The origin of the Mongols is to a great extent still doubtful, but according to the physiological character they must be ranked here. In their language, too, there is an affinity with the Finnians. They inhabit the greater part of Hungary.

Intellectual and Moral character.—The higher class is on a par with the most talented in Europe, of a quick, lively disposition, generally hospitable, haughty, and cruel. The traits of the people are remarkable for their love of horsemanship, of women, for their hospitality and national pride; but they are deficient in enterprise.

VII. The *Tatar* variety of the Mongolian species of the genus Man.

Physiological character.—Body tall, and of what is commonly called middle size, face oval, nose rather broad and flat, mouth small, skin not so sallow or yellowish as with most Mongolian varieties, small bright black eyes, with oblique cut, hair dark brown and dark, often of a shining, and sometimes of a smooth appearance.

Intellectual and Moral character.—Courage, love of freedom, hospitality, grave manners, peacefulness, laziness.

Inhabits the southern parts of Russia (the northern coast of the Black Sea), the peninsula of Crimea, and the former kingdom of Astrucan (Volga).

Subvarieties.—1. *Nogaic Tatars*, north from the Caucasus, on the banks of the Kuban and Don, on the shores of the Black Sea, and that of the Sea of Azov.

2. The *Crimean* or *Taurian Tatars*, in the Governments of Taurida, Kherson, and Ekaterinoslav.

3. The *Cazan Tatars*.

4. The *Meschtcherjäken*, in the Governments of Kazan and Orenburg.

5. The *Baschkir Tatars*, in the Governments of Orenburg and Perm.

6. The *Kasimoch Tatars*, on the river Sumbeika, one of the tributaries of the Terek.

7. The *Kirgis Tatars*, between the Wolga and Ural rivers, and on the coast of the Caspian Sea.

VIII. The *Kalmyk* (Khalimik) *variety* of the so-called Mongolian species.

Physiological character.—Complexion brownish-yellowish-sallow, hair black and rather bristled, head square, cheeks prominent, eyes receding, small, colour of the eyes black, brownish, and greyish, coat oblique, nose broad and flat, stature middle, frame more slender than stout, great muscular power.

Intellectual character.—Cunning, disposition for depredations, nomadic habits, fond of an intoxicating liquor called *kumiss*, made of fermented steed milk.

1. Soonjac-Kalmyks,
2. Tsegot-Kalmyks,
3. Derbet-Kalmyks,

} Between the lower part of the Don and Volga rivers, from Grusinia to the Caucasus and the Caspian Sea.

Note.—To make these notes as complete as possible, mention may also be made here of the Gypsies, Zigeuner (German), Gitano (Spanish), Bohémien (French), Tatars (by Danes and Swedes), who, according to their physical character, belong to the Caucasian species, and probably have emigrated from the banks of the Indus, where there is still a tribe said to exist (Pottinger), called Tchingarees, who, in appearance and language, are like the Gypsies to be found in Europe. The Gypsies made their appearance in Europe about the 14th century. Their number is calculated from 400,000 to 600,000 individuals, spread over all countries of Europe. They are very numerous in Spain, the Austrian dominions, and part of Turkey.

Physiological character.—Slender and nimble in limbs, complexion yellow-brownish, black eyes, white teeth, limbs in good proportion. Temperament: bilious-nervous.

Intellectual and Moral character.—The former little developed, yet without natural talents, which they exhibit as soothsayers, robbers, &c. They have a disposition for a vagrant mode of life, different attempts to settle them in a fixed locality made by several governments (Prussia), have failed. No disposition for agriculture and trade. Their notions of private property little developed; in disposition cheerful and frivolous.

D.—Distribution of the different varieties over Europe, according to numbers. General Facts relative to the pure and mixed state of the different varieties.

I. Races of Men, as well as of other animals, improve by crossing; although, with regard to the former, in consequence of the want of direct experiments, we cannot state what cross-breeds would constitute the finest race. Yet sufficient indications of the correctness of this view are to be found in the fact, that in those countries in which there is a mixed population, not only are the finest specimens of

ETHNOGRAPHIC MAP OF GREAT BRITAIN AND IRELAND,

ACCORDING TO Dr GUSTAF KOMBST, F.R.N.S.C, M.H.S.P.S, &c.

BY A. K. JOHNSTON, F.R.G.S.

Geographical Miles 60 to a Degree

10 5 0 10 20 30 40 50 60

English Miles 69 to a Degree

10 5 0 10 20 30 40 50 60

Reference to the Colours

- Scandinavian-Gaelic
- Gaelic-Scandinavian-Gaelic
- Scandinavian
- Pictish-Teutonic-Scandinavian
- Pictish-Teutonic-German
- Pictish-Scandinavian
- Manx
- Welch
- Welch-Teutonic
- Cornish
- Saxon-Britun-Welch-Cornish
- Saxon-Frision-Anglian-Norman-English
- Belgic-Saxon-Frision-Scandinavian
- Erse-Scandinavian
- Erse-Pictish
- Erse-Anglo-Saxon-Scottish
- Erse-Anglo-Norman
- Erse or Irish
- Erse-Belgic-Scandinavian

ORKNEY Is

SHETLAND OR ZETLAND ISLANDS

ORKNEY ISLANDS

ISLE OF MAN

CORN.

Scilly Isles

William Blackwood & Sons, Edinburgh & London.

Engraved by W. & A. K. Johnston

Note.—The Basque is frequently considered to be quite different from the other Celtic dialects. But, as the inquiry into the peculiarities of this language may still be supposed to have been insufficient, the author ranks the Basque languages among the Celtic ones, as the Basque themselves, from all we know of them, must be a Celtic tribe.

d, *Greek*, with comparatively little admixture of Italian and Sclavonian, approaching by degrees to the purity of ancient Greek, spoken in Greece. (The ancient Greek, although having, at first sight, the appearance of a pure tongue, was a mixture of Celtic and Teutonic elements.)

e, *Finnian*, to be subdivided into different dialects, according to the countries inhabited by that subvariety of the Mongolian variety, and Magyar, or Hungarian, spoken in the country of which it bears the name.

f, *Tatar*, comprising the Crimean, Casan, Kingis, and other Tatar dialects, spoken in the Governments of the Russian Empire, which bear their respective names. The Turkish is a mixed Tatar dialect, spoken by the inhabitants of Turkey.

II. *Mixed.*

a, *Teutonic* prevailing; English, in Great Britain, and among the higher classes of Ireland. (United States of America, British Colonies.)

b, *Latin* prevailing, with an admixture of numerous Celtic dialects, according to the different subvarieties of the Celtic variety; Italian. French, Spanish, Portuguese, Wallachian, Romanic dialects spoken in the mountainous parts of the French Cantons of Switzerland, and in part of the Grisons.

G.—Religion of the different varieties.

General Facts.

I. All the different varieties of the Caucasian species (even out of Europe) profess Monotheism.

II. Christianity has been spread through the agency of the Teutonic tribes, and is as yet confined to those countries to which their influence has extended.

III. According as the natural organisation of the tribes constituting the Caucasian species is more or less favourable, they entertain more or less elevated notions of the Deity.

IV. Although the whole of Europe now, with the exception of a small portion of the inhabitants of the coast of the White Sea, confesses Christianity, yet the more spiritual mode of Christian worship is confined to the nations of Teutonic origin, whilst the more sensuous one, approaching to Polytheism, is universally practised among the Celtic and the Sclavonian nations.

V. The Reformation, the principle of which was *self-inquiry*, which is the natural consequence of the prevalence of the reflective faculties in man, and of an independent mind—of liberty in general—has, on account of its very nature and spirit, been confined, and will be confined, to the nations of Teutonic origin.

A.—*Monotheism.*

a, Christianity.

I. Teutonic, when pure, *Protestant*, only in some parts, as on the Rhine and in the south of Germany; and when mixed with prevailing foreign elements, *Catholic.*

Protestant.

a, With aristocratic-monarchial principles of church government, patronage being vested either in individuals or corporate bodies: Lutheran Church, Episcopalian Church, United Lutheran-Reformed (Presbyterian) Church.

Lutheran Church: Sweden, Norway, Denmark, parts of Finnland, Curonia, Esthonia, Livonia, Saxony, Hanover, Hamburg, Lübeck, Bremen, Frankfurt, Würtemberg, Hesse-Darmstadt, parts of Bavaria, Transylvania, part of Hungary.

Episcopalian Church: England, Ireland, and in single congregations in Scotland (United States of North America, and in the British Colonies).

United Lutheran and Reformed (Presbyterian) Church, commonly called *Evangelical:* Prussia, Nassau, Baden.

b, With democratic principles of church government, patronage being vested either in individuals or corporate bodies; Presbyterian (and *Reformed*) Church: Scotland, Holland, the German cantons of Switzerland, Hesse-Cassel, Geneva, Vaud, part of Valais, Neufchâtel.

c, With democratic principles of church government, patronage being vested in the congregation: Sectarian churches upon the Voluntary principle; Britain (U. S. of America): Antibaptists, Antimoniana, Antisupernaturalists, Antitrinitarians, Arians, Arminians, Athanasians, Baptists (General Particular Unitarians, or Old Baptists), Barbarians, Bible Christians, Biddelians, Cameronians, Chartist Church, Dunkers or Tinkers, Dunlists, Ebionites, Friends (Quakers), Hopkinsian Calvinists, Humanitarians, Hutchinsonians, Independents, Johnsonians, Kilhamites, Methodists (Arminian, Calvinistic, Independent, Unitarian), Millenarians, Mormonites or Latter Day Saints, Muggletonians, Nazarenes, Necessarians, Pedobaptists, Pandelphian Quakers, Pelagians, Quietists, Ranters, Relief Church, Sabbatarians, Sabellians, Sandemanians, Seceders, Shakers, Socinians, Southcottians, Sublapsarians, Supralapsarians, Swedenborgians, Unitarians, Universalists, Winchesterians, Wrasites; few or none on the Continent of Europe; among those tolerated on the Continent, and more extensively spread, are the Moravian Brethren, and the Mennonites.

II *Celtic, without exception, Catholic.*

Catholic.

With aristocratic-monarchial principles of church government, patronage being vested either in individuals or corporate bodies: a, Church of Rome; Belgium, France, Italy, Spain, Portugal, Austrian Empire, greater part of Bavaria, part of Würtemberg, Baden, Hesse-Cassel and Hesse-Darmstadt, Prussia, Rhenish Provinces, Poland, Hungary.

b, *Greek* Church: Russia, Moldavia, Wallachia, part of Servia, Greece.

III. *Sclavonian*, Greek and Catholic.

IV. *Finnian*, Grecian Church, and among the Lappoons, Finnians, and Quänians, also Lutheran-Protestants.

V. *Magyar*, Catholic Church.

VI. Tatars, to the Grecian Church and Mohammedanism.

b, Islamism: Tatars, and some hordes of the Tatars.

B.—*Polytheism:* Some of the Finnian tribes, as Samojedes, Lappoons, Quänians.

VII. *Kalmyks:* Lamaism and Schamanism.

H.—Political Constitution.

General Facts.

I. The Teutonic tribes have, in course of time, developed the different forms of *Representative Government* in the representative Monarchy and Republic. Representation was unknown among the nations of antiquity. Among the Teutonic tribes there are, at present, only the following four Swiss cantons, in which representation, in the commonly received sense, has never been known, viz., Uri, Schwyz, Unterwalden, and Zug. In these cantons, all grown-up men form what is called the *Landsgemeine* (meeting of the country), in which is vested the legislative power.

II. The Celtic variety, in its highest development, in the *Roman type*, has, after having gone through the different stages of a more or less aristocratic republic, closed with *despotic monarchy*, and a code of laws which, however finished in form, in consequence of the proceedings connected with it, and the fictitious principles upon which it is based, is wholly subversive of liberty. To the adoption of this system of laws by the states of the Continent, more especially the German empire, it is owing, to a great extent, that these nations have lost the liberty enjoyed by their forefathers. In England, where Teutonic freedom has lasted longest, and never was entirely shaken, the Roman law never gained a footing.

In modern times, the highest typus of the Celtic tribes, *the French*, have, in their Revolution of 1789, *proclaimed* the principles of universal equality, and unrestricted political liberty; they have, first of all Continental nations, re-introduced the ancient Teutonic system of judicial proceedings, publicity and trial by jury; but they have not yet succeeded in establishing civil liberty in their own land.

III. The Sclavonian variety has not been able to emerge from a state of internal slavery, although it has shaken off the yoke of foreigners (Tatars), and for the last hundred years has, in Russia, obtained a very powerful representative.

IV. The Magyar subvariety of the Finnian variety has, in its higher classes, shown, for ages, a spirit of great independence, and individual liberty.

I. *Teutonic variety: Representative (limited) Monarchy:* Sweden, Norway, Britain, Holland, the so-called Constitutional States of Germany, that is, Baden, the two Hessias, Bavaria, Würtemberg, Saxony, the Saxon Duchies, Mecklenburg, Hanover, and the smaller German States.

Absolute (unlimited) Monarchy: Denmark, Prussia, Austria (having all of them provincial states of a merely local character, and with a consultative vote).

Aristocratic Republic: Free and Hanse towns of Germany: Hamburg, Lübeck, Bremen, Frankfurt.
Democratic Republic: German Cantons of Switzerland (out of Europe, the U. S. of N. America.)
Prevailing Political Spirit: Representation.

II. *Celtic variety.*

1. Representative limited Monarchy (adopted from the Teutonic tribes): in Belgium, France, Spain, Portugal, and Greece; Neufchâtel, with the King of Prussia for a hereditary first magistrate.
2. Absolute or unlimited Monarchy: in Italy.
3. Democratic Republic: Cantons of Geneva, Vaud, Valais.
4. Aristocratic Republic: Canton of the Grisons, Ionian Islands, under the Protectorate of Great Britain, and S. Marino in the Papal States.

III. *Sclavonian variety.* (Lettons included.)

Absolute Monarchy everywhere, with the exception of the Republic of Cracow, which has an aristocratic constitution, but is, in fact, ruled by the Resident Ministers of the three so-called protecting powers, Austria, Prussia, and Russia.

IV. Finnian variety of the Mongolian species.

1. Absolute or unlimited Monarchy: Finnia Proper, the country of the Samojedes, and also in Curonia, Esthonia, Livonia, where indeed there are old representative constitutions, which, however, cannot prevent the Monarch from carrying out his pleasure.
2. Representative Monarchy, with a powerful Aristocracy: Hungary.

Turk, Tatar, and Kalmyk varieties of the Mongolian species: The two latter Nomadic—*Patriarchal system, and* in Turkey *Absolute Despotic Monarchy.*

Liberty of Press: Repressive measures of more or less rigour, either according to a particular system of laws upon the subject, or in consequence of the application of the articles of the common law on libels, seditious offences, &c.—*Great Britain, Norway, Sweden, Holland, Belgium, France, Switzerland, Spain, Portugal, and Greece.*

Preventive measures by means of Censorship: Denmark, Germany, Russia, Italy, Hungary.

Publicity of Judicial Proceedings and Trial by Jury (Teutonic system): *Great Britain, Belgium, France, Rhenish Prussia, Rhenish Hessia, Rhenish Bavaria, Greece. A certain extent of Publicity without Jury:* several cantons of *Switzerland, Norway, Sweden.*

Secret Tribunals and Proceedings exclusively on Paper (Roman system): *Denmark, Holland, Germany* (with the three exceptions mentioned), Hungary, several cantons of Switzerland, Italy, Spain, Portugal, Poland, Russia.

I.—General Conclusions, more or less of a practical nature, to be drawn from all the preceding facts.

I. Every individual, as well as every subvariety, variety, and species of the human race, has certain peculiarities of its own, as regards its physical, moral, and mental organization.

II. The mental and moral development of every individual, variety, &c., of the human race, at any given time of his or its existence, will be in accordance with his natural faculties (mental and moral organization), and the power of the circumstances which influenced their development; or, in other words, the mental and moral character of every individual, &c., is the result of his organization, and of the influence exercised upon it by circumstances, and of the reaction of the natural organization upon these developing circumstances (systems of education, political and religious institutions, position in life, &c.)

III. The result, then, of the intellectual and moral development of every individual, variety, &c., of the human race must be, to a certain extent, different from that of other individuals, varieties, &c.

IV. A nation, in the physical meaning of the word (those political combinations, called nations, being here out of the question), is an organism, consisting of an indefinite number of individual human beings of the same physical and mental organization, and speaking the same language.

V. As there are natural laws for the organization of individual man, so there must be natural laws for the growth and decline of nations, although we may not yet be acquainted with them.

VI. As nations are differently constituted, no form of government can be found, which, without material modifications, can be applicable, at the same time, to all of them.
The same, to a certain extent, applies also to religion.

VII. Nations, as well as individuals, can only be developed to the extent of the powers of their natural organization, so that even the best institutions, when adopted from abroad, cannot improve a people naturally unfit for receiving them.

VIII. A nation, generally speaking, may always be said to possess those institutions, civil, religious, and political, for which it is fit at the time.

IX. The history of mankind exhibits nothing but the development of the different races, varieties, &c., of the human family, partly apart, and for the last three thousand years as mutually influencing each other; so that a progress in the history of mankind is always indicated either by the appearance of a new stock of people on the stage of the world, or by the produce of a crossing of two races.

X. Nations, as something organic, have to pass through different stages of development. The critical periods of this development are indicated by changes in the form of government and of religious worship. These changes will be violent (Revolution) so long as the natural laws, according to which the development of nations takes place, are not understood by men, or when known, not acted upon; they will be of a harmless character (Reform) when these laws shall be generally understood and acted upon. (Revolution—evolution.)

XI. Nations already about to decay, may be partially regenerated by the infusion of new ideas or by crossing with other varieties, or by both agencies combined.

XII. In those political combinations, called nations, when of the same origin, living under the same form of government, and enjoying the same general degree of civilization, there will be, in consequence of the same natural influence upon the same constitution, an equal amount of virtuous and vicious disposition. (See Quetelet's excellent work, "Sur l'Homme.")

XIII. Among the nations belonging to the different varieties of the so-called Caucasian species, there is an evident tendency towards improvement, on an increasing scale. This is fully borne out by the history of the last three thousand years.

Note 1. The Author takes advantage of a reprint of the Notes to the Second Edition of the Ethnographic Map, to acknowledge the great merit which, in his eyes, is possessed by the following work, with which he unfortunately did not become acquainted till summer 1843:—" La Science Politique basée sur la Science de l'Homme, ou Théorie des Races Humaines." &c. &c. Par V. Courtet (de l'Isle).—Paris, 1838. This work contains by far the best reasoning upon the influence which race has exercised on the history of man that is to be found in any book. Of this eminent work the Author has induced a friend to prepare a translation into English.

Note 2. Besides the works quoted above, the student is referred, for further illustration of the subject, to *Blumenbach's* " De Generis Humani Varietate Nativâ."—Gotting., 3d Edit., 1795. *Blumenbach's* " Decades Collectionis Craniorum."—Gotting., 1790. *P. Camper* " Ueber den Natürlichen Unterschied der Gesichtszüge in Menschen verschiedener Gegenden und verschiedenen Alters."—Berlin, 1792. *Virey* " Histoire Naturelle du Genre Humain."—Paris, 1824. *Desmoulin's* " Histoire Naturelle des Races Humaines."—Paris, 1826. *Roulin & St Vincent's* " L'Histoire de l'Homme."—Paris, 1825. *Edwards'* " Des Caractères Physiologiques des Races Humaines, considérés dans leurs rapports avec l'histoire."—Paris, 1827. *Choulant's* " Drei Anthropologische Vorlesungen."—Leipzig, 1834. *G. Vrolik's* "Considérations sur la Diversité des Basins des Différentes Races Humaines."—Amsterdam, 1826. *F. M. Weber* " Die Lehre von den Ur—und Racenformen der Schädel und Becken des Menschen."—Düsseldorf, 1830. *R. Wagner* " Naturgeschichte des Menschen."—Kempten, 1831. *Van der Hoeven* in " Tydschrift voor Natuurlijke geschiedenis," vol. i., p. 4. *Cuvier's Deutsche Werk Jahresbeigh*, 1838, " Die Menschenracen." *Berthold's* "Menschenracen," in Encyclopadischen Wörterbuch der Medic. Wissenschaften, vol. xxiii., p. 44. *Lawrence's* " Lectures on Physiology, Zoology, and the Natural History of Man." *Morton's* " Crania Americana."—Philadelphia, 1840. *W. Oberndörfer's* " Atlas Ethno-Géographique, &c. Planches Ethnologique."—Paris and Leipzig, 2d edit., 1842. *J. Müller's* " Elements of Physiology," by Dr William Baly.—London, 1842, vol. ii. *Bowdwich's* " Deutsche Sprachkarte," &c.—1843.

Note 3. The three great varieties of the Caucasian species have been pointed out, the *Celtic by blue*, the *Teutonic by yellow*, and the *Sclavonian by red*. The subvarieties of these varieties have different shades of these fundamental colours. Wherever there has been a crossing of these varieties, or subvarieties, it is indicated by a mixed colour, in such a manner that the colour predominant in the mixture points out the predominant ethnological element. Thus green, in its different shades, points out a mixture of Celtic and Teutonic blood; flesh colour, and other tints mixed of red and yellow, &c., point out a mixture of Teutonic and Sclavonian blood. The same principle applies also to the varieties of the Mongolian species which inhabit Europe.

The names of the different varieties and subvarieties have been pointed out by adjectives (many of which are abbreviated on the map), as it appeared more convenient to distinguish the respective populations by names indicative of their origin, which could not have been done, if the substantives representing their names of the present day had been used; thus, e.g., the name of Pomeranians, Prussians, &c., does not convey any distinct allusion to their origin, but the compound adjective coupled with the mixture of colour, shows at once what they are. In some instances names have been used which do not indicate, it is true, a peculiar subvariety or particular mixture; but in such cases, the difficulty of pointing out the different constituent elements of such a population was too great to be overcome on a general map. Such instances are *Lotharingians, Rhinlanders*, &c.

AN

ETHNOGRAPHIC MAP OF GREAT BRITAIN AND IRELAND.

BY

DR. GUSTAF KOMBST, F.R.N.S.C., M.H.S.P.S., &c.

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INTRODUCTORY REMARKS.

Since the author of this Map published the first edition of his Ethnographic Map of Europe (1841), the study of Ethnography has made great progress in this country. Two years ago, an Ethnological Society was founded in London, for the express purpose of combining and concentrating the efforts of those who labour in this branch of science. Even the public in general has taken up the subject, and it is not at all uncommon now to hear conversations about the respective qualities, merits, &c., of this or the other race of men. It may, therefore, be considered a favourable time to produce an Ethnographic Map of Great Britain and Ireland, in order to show, in the same graphic manner as the Ethnographic Map of Europe, the local distribution of the different populations inhabiting Great Britain and Ireland. The author is fully aware that this first attempt must, to a great extent, in so far as details are concerned, be an imperfect one. But it will depend on the kind disposition of those who take an interest in Ethnographic studies, whether it shall remain long uncorrected and unimproved. With the aid to be found in the explanatory matter accompanying the Map, it will be easy for any one who, in the slightest manner, interests himself in such matters, to bring to the author's knowledge, in whatever way he may find proper, any improvements or additions which may occur to him from his own personal knowledge or observation. The Map has been constructed partly from personal observations made by the author, and partly by having recourse to the best authorities, authors as well as other individuals, who could afford trust-worthy information. And here the author begs to repeat a remark, which was made by him in the explanatory matter to his Ethnographic Map of Europe, viz., that far too little attention has, as yet, been paid to the actual appearance of the populations of the different parts of almost all countries of Europe. History, for hundreds of years, has been written more from books and from hearsay, than from an actual acquaintance with the physical, moral, and intellectual character of the nations spoken of. It is true, in many countries, the mixtures of races have been so many, and are of so long standing, that it is often very difficult to find out the primitive character of the population. But such is not the case in this country. Here we have to do with two varieties, and their respective subvarieties, of one species only, viz., with the *Celtic* and *Teutonic* varieties of the Caucasian species, and the cross-breeds issuing from a mixture of the two; which it requires no great knowledge or acuteness to distinguish from each other. But, notwithstanding this, there is a great deal of error prevailing relative to this subject, even among the best informed classes of society, as will become evident when the Scotch Highlanders are spoken of below. The colours which the author has adopted for distinguishing the two races and their crosses are the same as those adopted in his Ethnographic Map of Europe, viz., *blue* for the *Celtic* variety, and *yellow* for the *Teutonic*. The different subvarieties of these varieties, so far as they could be ascertained, have been pointed out by different hues of *blue* and *yellow*; the different cross-breeds by lighter or darker hues of *green*; the lighter ones pointing out in the mixture a prevalence of the Teutonic element—the darker ones, that of the *Celtic* one. To avoid misconceptions, it may also be stated, that even in those tracts of country where the one primitive colour, *blue* or *yellow*, appears quite unmixed, cases of crosses more or less frequent or extensive do occur; but in comparison with the whole mass of the population, they constitute only so small an element that they could not be taken into account. The author will, however, gratefully receive any communication tending to show that the one or the other primitive element (*Celtic* or *Teutonic*) occurs as an exception among a population of an opposite character, to such a considerable extent that it can be pointed out on a general map. As a matter of course, towns, more especially larger ones, will always present a mixed population in a country which is peopled by two different races.

Great Britain and Ireland are inhabited by people belonging to two different varieties of the Caucasian species, viz., the *Celtic* and the *Teutonic* variety. Before we proceed to give an account of the distribution of these two races over the surface of the countries mentioned, it will be necessary to state what their respective ethnographic character is. We may be allowed to copy this explanation from our Ethnographic Map of Europe, as the definition there given of the two varieties in question is short, and fully intelligible :—

Celtic variety. *Physiological character.*—Dark (sallow) complexion, dark brown eyes and black hair, with a disposition to turn grey at an early age, and to fall out (bald-head), commonly not curled, stature of middle size, slender make, legs curved somewhat inwards, as in females, comparatively narrow chest, narrow hips, face and upper part of the skull the exact form of an oval, heels and ankles slender, feet small. Temperament: bilious and bilious-nervous prevailing.

Intellectual and Moral character. Quickness of perception, great powers of combination and application, disposition for concentrating political or administrative power, love of equality, of society, of amusement, of glory, want of caution and providence, prevalent disposition for sexual intercourse, gallantry, want of respect for human life. Want of penetration, of desire for personal independence and political freedom; national vanity. Disposition to superstition and hierarchy. Foundling hospitals. In most Celtic countries no law regarding paternity or for the sustenance of so-called natural children by the father. Fine blandishing manners, great external politeness, without inward sympathy. Irascible, not forgetful of injuries, little disposition for hard work. Bad seamen, and not fit for colonizing.

Physiological character, as given by George Combe, Esq. (See Kombst's Ethnographic Map of Europe.) The *Celtic head* is long from front to back, moderate in breadth, and moderate in height. Among the organs of the *animal propensities*, *philoprogenitiveness*, *adhesiveness*, *concentrativeness*, and *combativeness* predominate. *Destructiveness* is considerable, but less than *combativeness*. *Self-esteem* is large, and *love of approbation* rather large. The coronal region is generally little elevated above *conscientiousness* and *morality*: that is to say, the region of the *moral organs* is only moderately developed, but *veneration* is larger than benevolence and conscientiousness. The *intellectual* organs, also, are only moderately developed. In so far as I have had the means of observing, the different varieties of the Celtic race differ considerably from each other in the intellectual organs. The Scotch and Welsh Celts have the reflecting organs as largely developed as the knowing organs, while the French and Irish Celts have the knowing organs much more fully developed than the reflecting. In the Scotch and Welsh Celts *cautiousness* is fully developed, while in the French and Irish Celts it is much less so in relation to the other organs. *Ideality* is deficient in the Celts.

Teutonic variety. *Physiological character* :—Fair complexion, fair, often flaxen, reddish, golden-coloured smooth hair, commonly not curled, large blue eyes, ruddy cheeks, broad high brow, skull larger and rounder than in the Celtic variety, bones thicker, chest broader, so the hips, legs straight, heels and ankles strong, feet often large, even clumsy when compared with the Celtic variety, greater strength of muscle, tallness of figure, above what is called the middle size, skull and face of a form that approaches nearer to a half-circle, to which the thinner end of the oval is added; disposition to become corpulent. Temperament: sanguine, nervous, and phlegmatic prevailing.

Intellectual and Moral character. Slowness, but accuracy of perception; general slowness, but depth and penetration of mind; not brilliant for witticism like the Celtic variety, but distinguished by acuteness; want of concentrativeness. Fondness of independence, it being valued more highly than equality of condition or rank. Self-government in all spheres of life. Provident, cautious, reserved, hospitable, but not sociable on a large scale; with aristocratic-conservative tendencies, and fond of titles and social distinctions. Respect for women, without assuming the Celtic character of frivolous flippancy. No foundling hospitals. Spirit for benevolent foundations. Recklessness regarding other nations' rights, overbearing haughty spirit. Sincerity; forgetfulness of received injuries. Musical talent in most Teutonic tribes great. Skilful seamen, adventurous, distinguished for cleanliness, on the whole, fond of spirituous liquors. (For explanation see Liebig's "Animal Chemistry.")

Physiological character, as given by George Combe, Esq. (See Kombst's Ethnographic Map of Europe.) The Teutonic head is very different. It is very broad, but not long from front to back; the predominating animal organs are *amativeness*, *destructiveness*, *acquisitiveness*, and *adhesiveness*. *Combativeness* and *alhesiveness* are inferior in size to the foregoing; and *philoprogenitiveness* is not so generally large as in the Celts, especially in the male sex. *Concentrativeness* is generally deficient in the Teutonic race. The coronal region, that of the moral sentiments, however, is far larger than in the Celtic race. The forehead has generally large *benevolence*, *veneration*, *wonder*, *conscientiousness*, and *firmness*, and many individuals have also much *ideality*, although many are deficient. *Love of approbation* is larger than *self-esteem*, although both are considerable. The Teutonic intellectual organs are much larger than those in the Celtic race; the forehead is broader, and hence there is more capacity for music in the Teutonic. The Teutonic intellect has large organs of *comparison* and *causality*—the latter generally larger than the former, which gives a love of abstract and profound thinking; but *individuality* and *eventuality* are generally deficient; the consequence of which is, that the Teutonic race is far fonder of abstractions and speculations than of the study of actual objects and events, with a view to reduce the knowledge of them to practice. It lives in a world of feeling and speculation, much more than in one of accurate observation and practical application. The Teutonic race is distinguished for simplicity of character, benevolence, and honesty; yet it is passionate, and, when excited, can commit devastations with terrible energy. It is also prudent; for cautiousness as well as *secretiveness* is large. The Teutonic race is deliberate and slow.

Besides the characteristic marks of the two races inhabiting Britain which are given above, it would also be advisable to have recourse to their religious and political development, as stated in connection with other peculiarities, and in connection with other races, on the Ethnographic Map of Europe. The principal points of difference will be stated below. But, to make the subject quite clear and easy, and to dispel all prejudices of whatever kind beforehand, it will be indispensable to refer to some facts relative to the physical character of nations. We quote again from the Notes to the Ethnographic Map of Europe :—

I. *The physiological character of a nation lasts longer than its language.*

Proof.—The Normans in France, the Lombards in Upper-Italy, the inhabitants of the Butt of the Isle of Lewis, one of the Western Islands of Scotland, who speak Gaelic, although they are of pure Teutonic origin, the inhabitants of several districts of the Scottish Highlands and of North Wales, several parts of Modern Greece, the inhabitants of the latter of which are undoubtedly of Sclavonian origin, and yet speak Greek the so-called White Calyrbs in the Atlas, who speak an Arabian dialect, although they are a remnant, of the Vandals.

II. *The same physiological character in two tribes or nations is an indubitable proof of the same origin.*

Proof.—Self-evident, and corroborated by historical accounts of settlements in different countries of Europe. Thus, in several parts of Scotland, you find still the Germans of the north-west of Germany, the Norwegians, &c.; and in parts of England the Norwegians, Danes, and Saxons of old; and in Normandy the Norwegians of old—although the languages spoken in the different countries mentioned vary now to a great extent.

III. *Similarity of language in two or more tribes or nations, induces only a supposition in favour of the same origin.*

Proof.—Everybody would, without a knowledge of the physical character of several tribes or clusters of inhabitants in Scotland, Greece, France, &c., suppose they were of the same origin with their neighbours, from their speaking the same language; whilst the fact is, that they have only assumed this language in course of time, according to what seems to be a natural law, namely, *that the language of superior development prevails over that of inferior culture, if the numbers of the conquerors are at all in proportion to that of the conquered nation.* This is exemplified by the Teutonic tribes, who conquered Britain, and colonized (in the twelfth and thirteenth centuries) the north of Germany, then possessed by Sclavonian tribes; by the Romans in France, Spain, and Portugal; whilst, on the other hand, the Teutonic tribes, who invaded Italy, France, and Spain, lost their language, for the reasons assigned.

IV. *Even in the so-called Caucasian species of the genus Man, there are to be found two distinct shades of complexion, the fair one (Xanthous), and the sallow or darker one (Melanous), each connected with constitutional peculiarities of frame, temperament, &c.*

Proof.—The Celtic variety, which is dark (Melanous), whilst the Teutonic is fair.

V. *In the crossing of these two shades, the darker one prevails over the fairer one in complexion, colour of eyes and hair; the fairer one predominates, on the other hand, over the darker one, so far as frame of body, and frequently so far as temperament, are concerned.*

Proof.—The Lombards, Castilians, Catalonians, Arragonians, inhabitants of the Franche-Comte, and of North Germany. In the former, the complexion is dark, but the frame of the body is still Teutonic; in the latter (North Germans), the frame is often a mixture of the Sclavonian and German, but the darker complexion in the mixture commonly prevails.

It is, however, but fair to add, that, in consequence of the great variety of crosses, fair complexion, blue eyes, and fair hair are sometimes found with a Celtic form of skull and with a Celtic frame of body.

The two races inhabiting Great Britain and Ireland—viz., the *Celtic* one and the *Teutonic* one—are here placed in that order merely for an historical reason, not to point out any supposed or real pre-eminence of the one above the other; for the *Celtic* variety is *prior* in date to the *Teutonic* in this country; the whole west of Europe being originally, so far as our historical knowledge goes, inhabited by the former.

Let us now first enumerate the different subvarieties of the *Celtic* variety inhabiting Great Britain and Ireland, before we proceed to the task of stating how the different Teutonic tribes, which at the present day inhabit the United Kingdom, came to settle in it.

I.—CELTIC VARIETY.

A. Celtic Variety.

I. The *Gaelic* subvariety of the *Celtic variety*, inhabiting the greater portion of the Highlands and the Western Islands of Scotland. This subvariety, although it has maintained its original language, has become so greatly mixed in course of time, that it will be impossible to assign to it a specific and physical character, applicable to all the inhabitants of the different parts of the country just mentioned. To use the words of Dr M'Culloch, as one of the best authorities on the subject ("Highlands and Western Isles of Scotland," vol. iv., p. 294), "The original Celtic breed has been modified by the Gothic (Teutonic) blood in these several manners:—By the Picts, by the Belgic-Dalriadans (?), by the early Norwegians and Danes in the north, by the Danish Vikings and the Norwegian government of Magnus Barefoot, and by the intercourse during a long period between the Irish Ostmen of Dublin and of that eastern coast and of the western of Scotland. Subsequently, and during the same period, that of the Highland Magnates, at least, has been modified by the settlements of Anglo-Normans, Anglo-Saxons, Flemings, and Low-country, or Saxon, or Pictish Scots."

It is astonishing that, notwithstanding the excellent treatise on the "Origin and Races of the Highlanders," published by Dr M'Culloch, in the 4th volume of his "Highlands," &c., twenty years ago, the subject of the nature and origin of the Highland population should still be so generally misunderstood. It is scarcely possible to meet with a Highlander who is not proud of his Celtic origin, and pure descent; although nature, with undeniable distinctness, has expressed in his stature, and very frequently in his blue eyes and fair hair, that he is of true Teutonic origin. There is scarcely any other population in any country extant with regard to which such mistakes are daily committed concerning its origin; and those not by strangers, but by the very people themselves. It has elsewhere been shown by the author (see Ethnographic Map of Europe), and is admitted by the highest authorities, that similarity of language does not constitute an indubitable proof of the same origin among people in a country which is inhabited by different races. It is not intended to go through the whole of the arguments brought forward by the writers on the subject of the origin and race of the Highlanders of Scotland. It is sufficient to refer to Pinkerton, M'Culloch, and Dr Clement (Die Nordgermanische Welt, &c., Copenhagen, 1840), Fallmerayer (Geschichte des Kaiserthums von Trapezunt, München, 1827), to leave no doubt where the truth of the question lies. But every one acquainted with the Highlanders may examine the different points bearing upon this inquiry for himself. He will then find that the higher

predominance in the middle and higher classes. At *Birmingham*, and *Manchester*, and *Leeds*, the Celtic population, in consequence of the continued immigration of the Irish, is considerably on the increase. The same is the case in *Glasgow*. In Edinburgh, the Teutonic population, although the surrounding country is almost purely Teutonic, amounts to scarcely more than two-thirds of the whole number of inhabitants. In *Belfast* the Teutonic population (including, as in the former instances, also those crowds which are more Teutonic than Celtic) has the predominance; in *Dublin*, by far the Celtic. In Cork, a good deal of Teutonic blood is to be found; but by far the great majority of the inhabitants are Celts. This applies also to *Limerick* and its neighbourhood.

III.—DISTRIBUTION OF RACES.

To facilitate a synoptical view of the distribution of the different races over the whole country, we give the following county list of *England*, *Scotland*, and *Ireland*, with the respective population annexed:—

I. England.

1. *Northumberland:*	Anglo-Teutonic-Pictish (?)-Danish-Northman-Scandinavian.
2. *Cumberland:*	Pictish (?)-Teutonic-Danish-Northman-Scandinavian.
3. *Durham:*	Saxon-Teutonic-Danish-Northman-Scandinavian.
4. *Yorkshire:*	Saxon-Anglo-Teutonic-Danish-Northman-Scandinavian.
5. *Westmorland:*	Pictish (?)-Teutonic-Danish-Northman-Scandinavian.
6. *Lancashire:*	North of Kendal, Teutonic-Pictish (?)-Danish-Northman-Scandinavian. South of Kendal, the race is mixed Teutonic-Celtic.
Manx:	Manx-Celtic, with an admixture of Northman-Scandinavian.
7. *Cheshire:*	Anglo-Saxon-Teutonic-Anglo-Norman-Danish-Scandinavian, with a slight admixture of Briton-Celtic.
8. *Shropshire:*	
9. *Herefordshire:*	
10. *Monmouthshire:*	
11. *Nottinghamshire:*	
12. *Derbyshire:*	
13. *Staffordshire:*	
14. *Leicestershire:*	
15. *Rutland:*	
16. *Northamptonshire:*	
17. *Warwickshire:*	
18. *Worcestershire:*	
19. *Gloucestershire:*	
20. *Oxfordshire:*	
21. *Buckinghamshire:*	
22. *Bedfordshire:*	
23. *Lincolnshire:*	Saxon-Teutonic-Danish (Northman)-Scandinavian.
24. *Huntingdonshire:*	
25. *Cambridgeshire:*	
26. *Norfolk:*	
27. *Suffolk:*	Belgic-Saxon-Teutonic-Danish (Northman)-Scandinavian.
28. *Essex:*	
29. *Hertfordshire:*	
30. *Middlesex:*	
31. *Surrey:*	
32. *Kent:*	
33. *Sussex:*	
34. *Berkshire:*	
35. *Wiltshire:*	
36. *Hampshire:*	
37. *Dorsetshire:*	
38. *Somersetshire:*	Belgic-Saxon-Teutonic-Danish (Northman)-Scandinavian, with a slight admixture of Celtic.
39. *Devonshire:*	
40. *Cornwall:*	Cornish-Celtic, with a slight admixture of Saxon-Teutonic-Danish-Northman-Scandinavian.
Scilly Islands:	Cornish-Celtic.

Note.—See VIII., Teutonic subvariety.

Wales.

1. *Anglesey:*	Celtic (Welsh)-Cymric-Belgic (?)-Northman.
2. *Caernarvon:*	Celtic (Welsh)-Cymric-Belgic (?)
3. *Denbigh:*	
4. *Flint:*	
5. *Merioneth:*	
6. *Montgomery:*	
7. *Brecon:*	
8. *Carmarthen:*	
9. *Cardigan:*	Welsh-Celtic.
10. *Glamorgan:*	
11. *Pembroke:*	
12. *Radnor:*	

Scotland.

1. *Wigtonshire:*	Pictish-Teutonic-Celtic-Scandinavian.
2. *Kirkcudbright:*	
3. *Dumfries-shire:*	Pictish-Teutonic-Celtic.
4. *Ayrshire:*	Pictish-Teutonic, with a slight admixture of Celtic, with admixture of Danish (?)-Northman-Scandinavian on the coasts.
5. *Renfrewshire:*	
6. *Lanarkshire:*	
7. *Peebles-shire:*	
8. *Selkirkshire:*	
9. *Roxburghshire:*	
10. *Berwickshire:*	
11. *East-Lothian:*	
12. *Mid-Lothian:*	
13. *West-Lothian:*	
14. *Stirlingshire:*	Pictish-Teutonic-Celtic.
15. *Fife:*	Pictish-Teutonic-Scandinavian.
16. *Clackmannan:*	
17. *Kinross-shire:*	Pictish-Teutonic-Celtic.
18. *Dumbartonshire:*	
19. *Argyleshire:*	Gaelic-Celtic-Pictish-Teutonic-Scandinavian.
20. *Bute-shire:*	Gaelic-Celtic-Scandinavian.
21. *Perthshire:*	Pictish-Teutonic in south and south-east, Pictish-Teutonic-Gaelic-Celtic in the north and north-west.
22. *Forfarshire:*	Pictish-Teutonic-Danish-Scandinavian.
23. *Kincardineshire:*	
24. *Aberdeenshire:*	
25. *Banffshire:*	Pictish-Teutonic-Danish-Northman-Scandinavian.
26. *Moray:*	Pictish-Teutonic-Celtic-Danish-Northman-Scandinavian.
27. *Nairnshire:*	
28. *Inverness-shire:*	Gaelic-Celtic-Danish-Northman-Scandinavian, the Scandinavian element prevailing on the coasts.
29. *Cromartyshire:*	
30. *Ross-shire:*	
31. *Sutherland:*	
32. *Caithness:*	
33. *Orkney and Shetland:*	Pictish-Teutonic-Danish-Northman-Scandinavian, with an admixture of Celtic.

Ireland.

1. *Wexford:*	Irish-Celtic-Danish-Northman-Anglo-Norman.
2. *Kilkenny:*	Irish-Celtic-Belgic-Anglo-Norman.
3. *Carlow:*	Irish-Celtic.
4. *Wicklow:*	Irish-Celtic-Danish-Northman-Anglo-Norman.
5. *Dublin:*	
6. *Kildare:*	
7. *Queen's County:*	Irish-Celtic.
8. *King's County:*	
9. *Westmeath:*	
10. *Longford:*	
11. *Meath:*	
12. *Louth:*	Irish-Celtic-Danish-Northman-Anglo-Norman.
13. *Cork:*	Irish-Celtic-Belgic, with admixture of Danish-Northman-Scandinavian.

Ireland.—*Continued.*

14. *Kerry:*	Irish-Celtic.
15. *Limerick:*	Irish-Celtic, with admixture of Danish-Northman-Scandinavian.
16. *Tipperary:*	Irish-Belgic-Celtic.
17. *Waterford:*	Irish-Celtic, with admixture of Danish-Northman-Scandinavian.
18. *Clare:*	Irish-Celtic-Danish-Northman-Scandinavian.
19. *Cavan:*	
20. *Fermanagh:*	
21. *Monaghan:*	
22. *Armagh:*	
23. *Down:*	Irish-Scottish-Pictish-Teutonic-Danish-Northman-Anglo-Norman-Scotch-Irish-Celtic.
24. *Antrim:*	
25. *Londonderry:*	
26. *Tyrone:*	Irish-Celtic.
27. *Donegal:*	Irish-Celtic-Danish-Northman-Scandinavian on the coasts.
28. *Galway:*	
29. *Mayo:*	
30. *Roscommon:*	
31. *Leitrim:*	Irish-Celtic.
32. *Sligo:*	

Note.—The population of the different counties of Great Britain and Ireland has been pointed out by adjectives, of which those stand first which represent the greater amount of blood of the subvarieties of the Celtic and Teutonic variety inhabiting them. These counties of Ireland designated by Irish-Celtic, contain, nevertheless, a good sprinkling of Teutonic blood. This is more especially the case on the coast of the south-western and western counties, where there are often separate small communities to be found (mostly fishing villages) which are entirely of Teutonic, generally Scandinavian, origin.

How important, in a practical point of view, ethnographic studies are, more especially for the statesman, becomes evident by casting merely a rapid glance at Ireland. Here we find both races, the Teutonic and the Celtic, living together, subject to the same laws, and depending on the same influences of soil, climate, &c.; and yet, what a difference is exhibited in the social appearances of the two different races! In Ulster, and where people of Teutonic origin are settled, you find the same thriving prosperity, neatness of dwellings, &c., as in England and Scotland. It is not necessary to describe the contrast on the other side in words. It is but too well known. But, perhaps, it will be denied that this difference in the social appearance of the different populations is owing to a different natural organization; it will, perhaps, be said—Look at the disadvantages and at the oppression under which the Celtic (Catholic) part of the population of Ireland has groaned till within the last few years. To this it can be answered calmly,—1. The social disadvantages as to industry, commerce, &c., under which Ireland laboured till within the last sixty years, equally affected all the inhabitants of Ireland, whether Protestant (Teutonic) or Catholic (Celtic), and yet the Teutonic population contrived to thrive. 2. The pernicious system of leases, as existing in Ireland, has rather been the consequence of the improvident disposition of the Celtic population, than the cause of it; for it does not exist so generally, and to such an extent of subletting, in Ulster. 3. The Irish, wherever they go (look to the United States of North America) present, on the whole, everywhere the same state of misery and wretchedness. There must, then, be something *independent of the power of bad laws and bad administration*, which has caused, among the Celtic population of Ireland, all this evil; and we do not hesitate for a moment to ascribe it *mainly* to the want of provident habits, of a persevering industry, and of a disposition for hard and continued labour. In making this statement, we, of course, do not mean to underrate the baneful influence of bad laws and bad government, which have tended to increase and confirm the evil; we, on the contrary, consider it as so much the more a sacred duty on the part of the government of any country which has to deal with two populations, of which the one is, to a certain extent, incapable of taking care of itself, and pursuing unguided or unassisted the path to prosperity, to make wise provisions, which tend to lessen the disadvantageous influence of an inferior natural organization in the matters just alluded to. To apply this to Ireland, it would seem that more of centralization ought to exist in the government of the Celtic portion of the population, more of *paternal* care to be exhibited than is necessary, or even will be admissible, with regard to the Teutonic population of that country. All Celtic populations (see notes to Kombst's Ethnographic Map of Europe) have strongly centralized governments—require more to be taken care of by their respective governments—do nothing or little of their own accord, but require a stimulus from without—and have, of course, less free political institutions than the Teutonic populations. What ought to be done with regard to details in Ireland, it is out of place here to mention; only so much may still be said on that question as is within the scope of the present inquiry, namely, that a great benefit would be conferred upon Ireland, and consequently, also, upon Great Britain, if extensive English or Lowland Scotch colonies were established in all parts of Ireland; which would soon morally control the improvident tendencies of the Irish character, and, in course of time, produce a cross-breed, in which the superior qualities of the Teutonic race would be propagated.

Looking at the religious convictions of the different populations of Great Britain, we find (as was already established as a fact in the notes to the Ethnographic Map of Europe) that, on the whole, the *Teutonic* race is *Protestant*, and the *Celtic* one *Catholic*. It does not enter into our purpose to inquire here why this is so. The fact, however, is undeniable.

As to the political institutions of this country, it needs scarcely to be said, in a publication of this kind (principally intended for the inhabitants of this country), what it is. It is a *representative-aristocratic-democratic-monarchy*; that is to say, a constitution in which all political elements of society are more or less acknowledged and invested with power. The prevalent political sentiment of this country is undoubtedly *conservative*, in the best sense of the word, with a powerful under-current of *democratic tendencies*. This gives power and strength to the political and social body of this country, and makes revolutions by physical force almost impossible. It can be said, without assumption or pretension, that the body politic of Britain is in a sounder state of health than any other in Europe; and that those know very little of this country who, led away by what they see in France, always dream of violent and revolutionary changes in the constitution. Great Britain is the only country in Europe which has had the good fortune to have all her institutions worked out and framed by her in a *strictly organic* manner—that is, in accordance with organic wants, which require different *conditions* at different and *successive* stages of national development—and not by *theoretical experiments*, as in many other countries, which are still in a state of excitement consequent upon these experiments. The social character of the people of this country, besides the features which they have in common with other nations of Teutonic origin, is, on the whole, domestic, reserved, aristocratic, and exclusive.

IV.—DISTRIBUTION OF LANGUAGES.

The language of the inhabitants of the United Kingdom differs, of course, according to the race to which the people belong. We have thus two great stems of languages, viz.,

A. The *Celtic*, closely allied to the Semitic dialects of Asia (see "Dr Pritchard on the Eastern Origin of the Celtic Nations"), and represented in Great Britain and Ireland by the following languages, of which one, the Manx, stood perhaps only in the relation of a dialect:—

I. The *Cornish*, now extinct, but still spoken about the beginning of last century in Cornwall.

II. The *Welsh*, spoken in the whole of Wales.

III. The *Irish* or *Erse*, spoken in the greater part of Ireland.

IV. The *Manx*, spoken in the Isle of Man, but nearly extinct.

V. The *Gaelic*, spoken in the Highlands and Western Islands of Scotland.

B. The *Teutonic*, which exists in the two languages, called,

I. The *English*, spoken by a majority of the inhabitants of Great Britain and Ireland, either as their mother tongue, or at least as the language of business and mutual intercourse.

II. The *Scotch*, spoken by the Lowlanders of Scotland, and the inhabitants of the counties south-east and east of the Grampians, up to Inverness.

Both languages are split into a great many provincial or local dialects. A list of the principal provincial glossaries of the English and Scotch languages is to be found in Dr "Bosworth's Dictionary of the Anglo-Saxon Language." (London: Longman & Co., 1838, p. xxvii., in the note.)

That the *Scotch* is actually a language independent of the English, although of the same stock, and not, perhaps, as supposed by some, a deteriorated English or Saxon, there can be no doubt. But it is not the place here to write a treatise on the subject. Those who have hitherto treated on the subject, generally, did not know the German, or, at least, were quite unacquainted with the country dialects of Northern Germany, and with the historical development of the German language. Any person possessing this requisite knowledge, who chooses to make a comparison between the popular dialects of the north of Germany with those of Scotland, will soon be convinced that the Scotch is not derived from, or, as has been strangely enough supposed, deteriorated out of, the English, but belongs, with it, to the second branch of Teutonic languages. (See Ethnographic Map of Europe—Languages.) Whosoever wishes to form an opinion on the subject, needs only compare the most ancient remnants of the Scotch language with the old English or Anglo-Saxon, and he will at once see the difference. The supposed Danish origin of the Scotch language can easily be explained, from the circumstance of the Danish invasions and settlements in the north-east and east coast of Scotland; in consequence of which a considerable number of Danish words occur in Forfarshire, and other neighbouring counties.

classes of the inhabitants in the Highlands have either the distinctive marks of pure Teutonic origin, viz., large tall figure (compare also the Gartmore MS., quoted by M'Culloch, vol. iv., p. 253, which says, on this subject, "*The principal people being larger bodied than the inferior sort*"), blue eyes, and fair or reddish hair; or that they bear, at least, the distinctive marks of a cross-breed, in which the Teutonic character prevails in the frame of body, and often, also, in the occurrence of bluish or grey eyes, although hair and complexion may be dark. Also among the lower classes in the islands as well as on the mainland, a great many individuals of pure Teutonic character occur; the majority there being undoubtedly a cross-breed, in which, on the whole, the *Teutonic* character prevails. Every one who has seen the Highland regiments throughout the world, and especially Highland regiments, of which most of the men are Highlanders, will acknowledge the correctness of this statement. The Highlanders, in short, are far more Teutonic than they themselves know, or will acknowledge. They are, in every respect, far more nearly allied to their Saxon Lowland neighbours than to any Celtic race that is extant in its former purity; *e.g.*, the people in Cornwall, Little Brittany, the Auvergne, &c. In maintaining this point, which is fully brought out by undeniable facts, the author is neither prejudiced in favour of the one nor the other race. He knows full well what great nations the Celtic race has produced; but he is also *aware of* the fact, that the *pure* Celtic nations, for the last two thousand years, have been on the decline, and that the whole modern civilisation of the world, since the establishment of Christianity, is owing to the Teutonic race.

II. The *Manx* subvariety, inhabiting the Isle of Man, which is only quoted here as a separate subvariety, as it formerly had, and, to a certain extent, still has, a language distinct from other Celtic tribes—which, however, stood more in the character of a particularly marked dialect than as a separate language; *e. g.*, the Welsh and the Irish of the present day. Even in the Isle of Man, in consequence of the Norwegian rule, which lasted for several hundred years (from the seventh to the middle of the thirteenth century) a sprinkling of Scandinavian (Teutonic) blood is to be found in most parts of the island.

III. The *Erse* or *Irish* subvariety, inhabiting the greater part of Ireland, and being spread by immigrations over most of the manufacturing districts of England and Scotland. It would be idle to expatiate here on all the hypotheses that have been advanced regarding the origin of the Irish—whether Phœnician, Milesian, or Iberian—because that point, most probably, will ever remain unsettled. The special character of this subvariety, beyond the general character of the variety, is as difficult to state as that of the *Gaelic* in the Highlands of Scotland; as here in Ireland, too, there have been immigrations of Teutonic tribes, and consequent mixture of races, from a very early period; the circumstances connected with which will be mentioned afterwards. Here only a few names may be given. The original inhabitants of the country were partly conquered and crossed,—1. By *Teutonic Belgæ* from Gaul and England, who settled in the South (300 (?) years before Christ). 2. By *Scandinavian* or *Germana Scythæ* (*Scots*) in the *north*. 3. By *Picts* in the east. 4. By *Norwegians* and *Danes* in the east and south; in short, in almost all parts of the coast. 5. By *Anglo-Normans* in the east and north. 6. Colonized by *Englishmen* in Londonderry. 7. By *Lowland Scotch* in Ulster. From this it is evident that there is a great deal, and only of pure, but also far more of mixed Teutonic than of Celtic blood in Ireland; the latter, indeed, occurring in almost all parts of the country—the western and south-western country perhaps excepted. Yet Ireland is far less assimilated to the Saxon race (Teutonic) than the Highlands of Scotland, or almost any other extensive part of Britain, inhabited by an originally Celtic population. It has been said, "Ireland has not been sufficiently conquered." So far as this refers to a crossing of the races, which is always the ultimate result of conquest, it is true. But it is undeniably true, also, that the spirit of resistance, and often of rebellion against England, has proceeded more from the Teutonic (*Protestant*), or at least the mixed population, than from the real Celtic stock of the country. O'Connell himself is no pure Celt, but a cross-breed, approaching the Teutonic more than the Celt.

IV. The *Welsh* subvariety, occupying the different counties of Wales. It is probable that, at an early period, a Teutonic colony found its way to Wales (Belgæ?) which improved upon the original stock of people, and from which the blue eyes and a great many people in North Wales may be derived, as well as the decided resistance which the Welsh opposed to the Saxon invaders at a later period explained. (M'Culloch, vol. iv., p. 281.)

V. The *Cornish* subvariety, inhabiting Cornwall and the Scilly Islands. Whether these people came from Phœnicia, as some believe, or from Spain, or from the opposite coasts of France, it seems, at the present day, at least, impossible to settle. They are, in their appearance, far more purely Celtic than any of the other Celtic populations of Britain, taken as a whole. Yet their ancient tongue became extinct at the beginning of the last century.

It is scarcely in place to mention here, after the other Celtic subvarieties, the *Romans* also (see Kombst's Ethnographic Map of Europe) as a constituent element of the population of the British islands. It is true the Romans held Great Britain, or at least the greater part of it, for about five hundred years (*So* B.C.–426 A.D.); but as the Roman element in this country was merely represented by armies, which, to a great extent, were composed of foreigners, frequently even of Teutonic origin, and not of Romans, we can scarcely attribute great weight to their stay in this country, in so far as it might have influenced the physical and moral nature of the population. Of their language nothing has remained, as is evident from the Teutonic purity of the so-called Anglo-Saxon; and what is now found of Latin origin in the English tongue must be traced to a far later importation, viz., by the Normans, and still later, from the French. By looking into English books written about three hundred years ago, every one may convince himself that at that time the English language was more Teutonic than at the present day, great numbers of Frenchified Latin words having been introduced into English in the course of the seventeenth and eighteenth centuries.

II.—TEUTONIC VARIETY.

We come next to the

B. TEUTONIC Variety, of which we shall now detail the different subvarieties, in the historical order of their arrival in this country.

I. The (*Irish*) *Scottish* subvariety. This is evidently the oldest Teutonic colony in the United Kingdom, occupying, at a very remote age, the whole north of Ireland (Ulster), and swaying over the neighbouring Celtic tribes. They had come from Scythia, *i.e.*, Scandinavia (see below), according to *Nennius* (Hist. Brit., cap. v.), about 1700 (?) years before Christ. But whatever may have been the actual period of their arrival in Ireland, we have sufficient evidence from ancient writers (see Pinkerton, vol. i., pp. 116, 117), that they were entirely different to the Picts. For their Teutonic origin, besides the testimony to be found in the circumstance that they came from Scythia, we quote from Clement (p. 27) the following arguments:—1. They came from the north. 2. They came by sea in a fleet (Annals, iv. Mast. 3500). 3. The names of their leaders are Teutonic. 4. They are on friendly terms with the Picts on their arrival (see below, and Bede's Hist. Eccles. Anglor. i. 15). The subject is also discussed at full length by Pinkerton. (Vol. ii., p. 45, ff.) The name of *Scot* is, no doubt, the same with *Scyth* (isn). Every philologist knows, that the nature of vowels is very changeable, and that there is a regular interchange of consonants of the same class in words of different languages of the same origin, as well as in words of the successive periods of its development. Thus, in the Irish Gaelic MSS (Pinkerton, vol. ii., p. 47), *Scytiæ* for *Scotiæ*, and in the Latin writers of the middle ages Scotia, instead of Scoti or Scotti, in the same manner as in ancient writers there occur *Gothones, Gythones, Guttones, Gothones*, &c., for the Gothi. Thus Scotia and Scotland are indicative of the origin of the race, and synonymous in meaning with Scandinavian, as it is literally with *Gothi*, the sibilant S being in many instances dropped in words in two languages of the same origin, or in dialects of the same language, or in the same word at different periods of the same language. Compare the German S (ch) *wasge*, and the English *wing*; S (ch) *wench*, and *wank*, &c. How the Irish Scots came to invade Scotland (from 258 and 360 A.D.) (the country which afterwards received their name), will be found fully, and most ably and irrefutably, discussed by Pinkerton (vol. ii., chap. 2 and 3, p. 61, ff.), who treats the question of the nationality of Kenneth, who united the Scots (Dalriads) and Picts. (See p. 158, ff.)

II. The *Belgian* subvariety (*Firbolgeu*), who had settled in the south of Britain not long before Cæsar made the first expedition to this country (300 BC.?). That these *Belgæ* were of Teutonic origin is settled beyond doubt by him stating them to have been "Plerosque Belgas esse ortos a Germania." (*Vide* Bell. Gall., lib. ii.)

Tacitus (Vit. Agricol., cap. xi.) also states, with regard to them: "*Galles vicinum solum occupasse credibile est*;" which corroborates Cæsar's statement of the Teutonic origin of the *Belgæ*. Even at the present day that part of the Continent inhabited by the Belgæ consists, to a great extent, of inhabitants of Teutonic origin. It is probable, but by no means yet established by sufficient historical evidence, that the Belgæ sent a colony to North Wales, and another to the south of Ireland. (M'Culloch, vol. iv., p. 281, ff.)

III. The *Caledonian* subvariety. This name may be allowed here for want of sufficient evidence as to what subvariety of the Teutonic variety the inhabitants of Caledonia (ancient Scotland north of the Spey and Inverness) belonged, who are, by the testimony of Tacitus, said to have been people of Teutonic character (see Tacitus, Vit. Agricol., cap. xi.); "Habitus corporum varii atque ex eo argumenta, *numquæ rutilæ* Caledonicus inhabitantium *comæ, magnæ artus*, Germanicum originem asseverant." Whether these people were *Picts* (see IV. subvariety), or whether they belonged to any other of the many Teutonic tribes which in ancient times—probably long before the Christian era—invaded Britain, it is difficult to decide. From what follows, we may conjecture them to have been Picts.

IV. The *Pictish* subvariety. The best work on this subject is Pinkerton's History of the Picts ("An Inquiry into the History of Scotland preceding the reign of Malcolm III.," &c. By John Pinkerton. Edinburgh: James Ballantyne & Co., 1814, 2 vols. 8vo), who, to my unprejudiced mind, must be considered to have settled the question as to the Teutonic origin of this people. There are only a few arguments in favour of this origin:—1. A great many names of the Pictish kings are evidently Teutonic, only a little disfigured by Celtic terminations. Such names are, among others, Canut (Canut), Combust, Gere, Tineus, Garnard, Drust, Dunevald (Donivald), Gorm (Gyrm), Brude, Indulf, Luthren, Erp, Aniftude, Uven, Urpar, Gote, &c. 2. *Beda* (Hist. Eccles., lib. i., cap. 1) and *Geoffrey of Monmouth* (Britannia Utinopiæ Regum et Principum Origo, &c., lib. i., cap. 1), both mention that the Picts came by sea from Scythia. SCYTHIA, as is well known, applied in ancient times to all those countries in the north, and especially north-east of Europe, north of the Black Sea, which were inhabited by nations of Teutonic and Sclavonian origin. It is often used synonymously with *Sarmatia*. But from *Jornandes* down to a late period of the middle ages, it applies distinctly to *Scandinavia*. As the Picts thus came from Scythia by sea, we have only the alternative of tracing them from people of *Teutonic* or of *Sclavonic* origin. The *Sclavonian* tribes have never been distinguished for their maritime skill nor for their piratical expeditions. Both, however, was the case with all the Teutonic tribes of Northern Europe. Further, we do not find the least trace of any Sclavonian settlement in this country. We therefore may, without being accused of rashness, conclude, that the Picts were a tribe of Teutonic origin. From what part they came, it will be impossible exactly to ascertain. But if we may judge from the appearance of the people in those parts of Scotland (Lowlands) which are undoubtedly inhabited by the descendants of the ancient Picts, and if we further turn to account the testimony of the language of the Lowlands of Scotland, we may, perhaps, be entitled to infer, that the greater mass of these Picts must have come from the coasts of Germany (and, perhaps, of Denmark) bordering upon the North Sea. Both authors (it is, however, probable that *Geoffrey* of Monmouth merely copied from Beda, as was done very frequently in the middle ages) further mention, that the Picts came to that part of Scotland which we already, in Tacitus' time, find inhabited by a Teutonic race (see above), after first having gone to the north of Ireland, already inhabited by the Scots, and there being refused admittance. Our authorities further state that the Picts, who had no women with them, got wives from the Scots in Ulster, as the Britons were not willing to give them their daughters. In the following circumstance, there is another argument in favour of the Teutonic origin of the Picts. 3. The whole Lowlands of Scotland are inhabited at the present day by a Teutonic race, of which we cannot trace the origin to any known immigration of Teutonic colonies. It is, therefore, natural to suppose, that the Lowland population is actually the offspring of the ancient Pictish population, as the Picts, after having first settled in the north and north-east of Scotland, came, in course of time, to possess themselves of the southern portion also. But it is said: If the Picts were of Teutonic origin, how did it happen that they were vanquished by the Scots from Ireland, who, from all that we know, must have been Celts?—but we know as well that the Celts in the long-run were always beaten by the Teutonic tribes.—How, then, should a Teutonic race, in this instance, have surrendered to a Celtic one? Further: If the Picts were a people of such consequence, as is frequently asserted, how did it come to pass that their very name has entirely disappeared? Both these questions can be easily, and, we think, satisfactorily answered. 1. The Picts were conquered (if conquered at all, which is more than doubtful—see Pinkerton, vol. ii., p. 160, ff.) by a kindred race, the Scots from Ireland (Dalriads); these Scots or Skylds being undoubtedly not Celts. (See above.) 2. Pinkerton, M'Culloch, and Clement, have answered the second question by referring to the analogous case of the name of England, which is derived from the Angles, who evidently formed a very small portion of the Teutonic invading force. Even the great majority of them going by the name of Saxons. We may further add, as a proof of the strange fate of the names of nations, that at the present day the descendants of a Teutonic race call themselves, notwithstanding, —"BRITONS" (as inhabitants of Great Britain), although they have nothing at all in common with the ancient Britons of this country.

It is another question to fix the date when the Picts came first to this country, as several immigrations of them in succession seem to have taken place. We agree with Pinkerton (see vol. i., pp. 207, 209) that the first colony of them may be supposed to have come about 200 or 300 years before the Christian era.

To explain how the Picts came to spread over the whole Lowlands of Scotland, and over the counties south and south-east of the Grampians, would lead us too far away from our purpose, which was simply to vindicate their Teutonic origin.

V. The *Anglo-Saxon-Jutish-Frisian subvariety*, conquering and filling, since the middle of the fifth century, first under Hengist and Horsa, gradually the eastern, southern, and even midland counties of Great Britain, more correctly, perhaps, the *Angles*, the *Saxons*, the *Jutes*, and the *Frisians*, should be classed apart, as we know that they settled in different localities; as the Jutes in Kent (A.D. 449); the South-*Saxons* in Sussex (A.D. 491); the West-*Saxons* in Hampshire, Dorset (A.D. 519); the East-*Saxons* in Essex, &c. (A.D. 527); the East-*Angles* in Norfolk and the neighbouring localities (A.D. 527); in Northumberland (Bernicia,) (A.D. 547); Yorkshire (Deira) (559); in Derbyshire (Mercia) (586). However, it is more than probable, that even from the very beginning these invaders did not consist of distinct bodies composed of individuals merely of the same tribe; but that, on the contrary, they were afterwards, like the Normans, composed of people of almost all the Teutonic tribes bordering upon the North Sea.

VI. The *Northman* subvariety, occupying, since the beginning of the eighth century, the Western Isles of Scotland, the Orkneys and Shetland Islands, and ravaging and conquering parts of the north-east coast of Scotland, and of the north and north-east coast of Ireland.

VII. The *Danish* subvariety, for more than a hundred years (since the end of the eighth century) omnipotent in England and Ireland; making descents, and establishing settlements on the eastern coasts of Scotland; in Northumberland, Yorkshire, and the whole south of England; and the south, principally the east, of Ireland.

VIII. The *Norman* subvariety. This subvariety (if this designation is at all appropriate here, as the Normans who came from Normandy were Scandinavians, mixed with Frisians, and other adventurers from the German coasts of the North Sea) offers the extraordinary phenomenon in history of having given up its original language within the course of 150 years (912–1066) after it first *permanently* settled in Normandy, and before it conquered England, for a tongue—the French—not of Teutonic part, of French. This was that Teutonic subvariety which, after the battle of Hastings (1066), took permanent possession of Britain, introduced the feudal system, at that time not known in this country, in the strict sense of the word, and exercised great influence over the destinies of the other allied races, over which it became predominant.

This *Norman* subvariety of the Teutonic variety, has, at the same time, been the last enemy which Britain saw on its shores, and to whom the inhabitants had to give battle on their own soil.

Since the eleventh century, then, the progress of civilisation of the different populations of Great Britain and Ireland, which had begun already several centuries ago, received a new impetus, and consisted chiefly in the mixture of races, the middle ages down to the present day. From all we have said before, that the English people are not an entirely or purely Teutonic race, but that the admixture of Celtic blood has been gradually swallowed up, not only in the midland counties of England, but even in the more western counties—Wales, of course, especially the southern part of it, excepted; that we may further infer, that while the inhabitants of the eastern and northern counties are (with very slight local exceptions, perhaps) entirely Teutonic, the mass of the English people, and of the Lowlands, and the eastern coasts of Scotland, is a cross-breed, with four-fifths, at least, of purely Teutonic blood. It has taken hundreds of years ere this intelligent, active, persevering, industrious race of Britain has come forth out of this process of mixture which was going on during the middle ages, and, as has been already stated, from the Conquest. Kombst's Ethnographic Map of Europe, a true and faithful one beings has been formed for which Britain is so justly famed. Every one who has seen the principal countries of Europe will unhesitatingly admit, that no finer men can be found than in the middle and higher classes of Britain, whilst female beauty, at least in England, is found inherent in individuals of all classes. The mixture of races, the female population of one English county, in which there has been a great deal of mixture of blood, has received, from its charming beauty, the name of the Lancashire Witches.

Note.—A pretty sure indication as to the origin of the first Teutonic settlers in most parts of England, and certain parts of Scotland, is given in the nature of the names of the localities (towns, &c.) in which they settled—certain terminations of such names being peculiar to certain Teutonic tribes. The most common terminations of Teutonic places in England are,—*ton* (town), *hem*, *by*, *thorpe* (thorp), *bury* (borough and brough), *forth*, *wreth*, *wick*, *bridge*, *ey* (ea), *south*, *burn*, *dale*, *field* (Norse, *fall*; in English frequently *fill*), *thwaite*. (See Clement's Nordgermanische Welt, p. 185.) Of these the following are of Scandinavian and *Frisian* origin,—*ham*, *by*, *field* (fell), *thorpe*, *wick* (wick); of Saxon,—*ton*, *forth*, *wick* (wick); and common in all Teutonic tribes,—*thorpe*, *bridge*, *ea*, *bury* (borough, burgh), *mouth*, *burn*, *dale*. The best information on Anglo-Saxon names of localities is to be found in H. Leo, "Rectitudines Singularum Personarum," &c. Halle: 1842. For common reference, may be quoted, Gibson's "Etymological Geography," &c. Edinburgh: Black, 1840. Clement (p. 186, ff.) gives a very extensive list of names of English, and also Scotch localities, terminating in *ham*, *by*, *fell*, *thwaite*, &c. See also Leo, "Rectitudines," chap. Die Angelsächsischen Ortsnamen, pp. 1–104.

If we were to make an *average calculation* as to the ethnographic quality of the blood in the population inhabiting Great Britain (for an accurate calculation will, for the present at least, be out of the question), we would most probably arrive at the following result:—

I. *Pure Blood.*

1. Teutonic in England, Scotland, and the east and north-east of Ireland,	-	10,000,000
2. Celtic in Cornwall, Wales, the Scottish Highlands, and Ireland,	-	6,000,000
		16,000,000

II. *Mixed Blood.*

1. *Teutonic* (that is, with prevalent Teutonic character) in England, Scotland, and Ireland,	-	6,000,000
2. *Celtic* (that is, with prevalent Celtic character) in Cornwall, Wales, the Highlands of Scotland and Ireland,	-	4,000,000
		10,000,000
Total of *Teutonic*, pure and mixed,	-	16,000,000
Total of *Celtic*, pure and mixed,	-	10,000,000
Sum total,	-	26,000,000

Note.—Large towns, which are more or less centres of civilisation, will always present (even in countries where the population, generally speaking, is pure—*e.g.* Copenhagen in Denmark, Christiania in Norway, Stockholm in Sweden, and Amsterdam in Holland, all of these countries being inhabited by a purely Teutonic stock, if we except the Finnish portion of Sweden) a great mixture of races. This is, however, more strikingly apparent in large towns in countries which have a mixed population; so that the averages of measurements, &c., made in such localities will, to a certain extent, differ from those of measurements made in the country. To apply this to our case: *London* has a population in which the Teutonic character greatly predominates, because the whole surrounding country, to a great extent, is purely Teutonic; and the Celtic element has come from a great distance (Ireland, Wales, and Scotland). In *Liverpool*, in consequence of the continual influx of Irish, more especially of the lower classes, the two national elements, the Teutonic and Celtic, may nearly balance each other, the Teutonic having the

V.—MISCELLANEOUS PHYSICAL STATISTICS.

In the following Tables, measurements are given of a number of persons belonging to different parts of Great Britain and Ireland. They are certainly very deficient, but they could not, at present, be made more complete.

I. Measures of soldiers, and of 562 civilians residing in Edinburgh, &c.

Average size of about 2000 Infantry Soldiers, measured in the Castle of Edinburgh by Mr Macdonald—viz., two Scotch and one English Regiment.

	42d Royal Highlanders.	79th Highland Light Infantry.	79th Regiment of Foot.
Average of Height:	5 ft. 8¾ in.	5 ft. 7¾ in.	5 ft. 7⅝ in.
" Head and Neck,	1014 "	1014 "	1013 "
" Body,	2048 "	2018 "	2045 "
" Feet,	2016 "	2018 "	2016 "
" Circumference of Chest:	1042 "	1045 "	1046 "
" " Waist,	2316 "	2316 "	2315 "
" " Hip,	4013 "	39 "	3915 "
The above Regiments were measured without their shoes.			

Average of Middle and Upper Classes.

Full Height of 562 Individuals.—

Average,	5 ft. 8¼	in.
" Head and Neck,	1054	"
" Body,	2568	"
" Feet,	2534	"

Average of Lower and Middle Classes.

Average,	5 ft. 7½	in.
" Head and Neck,	103	"
" Body,	25	"
" Feet,	24	"
The above were measured in their shoes.		

II. The following Tables are taken, the first from the valuable work of Henry Marshall, F.R.S.E., Deputy Inspector-General of Army Hospitals, "On the Enlisting, Discharging, and Pensioning of Soldiers," and the others from the "Edinburgh Medical and Surgical Journal," vol. xlii.

Table showing the Average Circumference of the Chests of the Recruits examined in the London District, from the 15th October 1856 to the 12th January 1859, inclusive, arranged according to the Height of the Recruits.

Height of the Recruits.	Town Recruits.				Country Recruits.				Aggregate.			
	No. examined.	Average size of chest.	No. found fit.	Average size of chest.	No. examined.	Average size of chest.	No. found fit.	Average size of chest.	No. examined.	Average size of chest.	No. found fit.	Average size of chest.
Ft. in. Ft. in.		In. dec.		In. dec.		In. dec.		In. dec.		In. dec.		In. dec.
5 5 to 5 6	85	32.44	58	32.24	23	32.77	20	32.66	108	32.51	78	32.37
5 6 to 5 7	423	32.65	278	32.19	235	32.71	197	32.80	658	32.15	476	32.44
5 7 to 5 8	293	32.94	197	32.53	103	33.11	93	33.15	396	32.62	290	32.79
5 8 to 5 9	122	32.57	79	32.81	56	33.00	47	33.18	178	32.70	126	32.95
5 9 to 5 10	50	32.76	33	32.59	28	33.78	23	33.57	86	33.08	56	33.06
5 10 to 5 11	44	32.54	27	32.94	13	33.61	8	33.81	57	32.77	35	33.14
5 11 to 6 0	20	32.92	16	33.60	3	33.67	2	33.60	23	33.02	12	33.23
And upwards.	4	32.38	1	32.66	1	33.00	1	33.00	5	32.56	2	33.50
	979	32.66	689	32.32	462	32.91	391	32.89	1439	32.87	1080	32.66

Comparative Statement of the Height and Thickness of Men round the Chest, in different Counties.

Regiments.	Average inches round the chest.	Average inches in height.
Highland Lanark,	39.74	67.39
2d Edinburgh,	38.78	68.84
Kinross,	39.07	67.39
Peebles,	39.53	69.26
2d Fife,	39.82	67.59
6th Lanark,	39.91	68.66
2d Argyll,	40.07	67.74
1st Argyll,	40.09	67.76
East Stirling,	40.09	68.66
Annan and Dalziels,	40.64	68.15
Kirkcudbright,	41.91	68.39

Average Heights of Men.

Heights.				Number of the different sizes in 100.
Ft. in.		Ft. in.		
5 4	and	5 5		12.3
5 6	"	5 7		37.3
5 8	"	5 9		31.2
5 10	"	5 11		13.5
6 0	"	6 1		2.0

Comparative Sizes of Men's Heads, as ascertained by actual Measurement, upon an extensive scale, in Retail Hat-shops in London and Edinburgh.

Inches circumference.	Edinburgh, No. in 100.	London, No. in 100.
19.5	0.000	.450
19.875	0.285	.164
20.25	2.285	4.842
20.625	6.285	11.696
21.	16.428	25.864
21.375	27.428	28.809
21.75	21.571	13.344
21.125	13.000	10.049
22.5	8.428	3.789
22.875	3.142	0.328
23.25	0.857	0.328
23.625	0.285	0.164
24.	0.000	0.000

Note.—Those who are partial to Ethnographic studies, and who may feel inclined to take measurements of the population of their respective localities, are requested to direct their attention principally to the following points:—*1. Form of head:* a, Small to be measured on its base as to circumference; b, From the root of the nose to the middle of the crown; c, From the middle of the crown to first of the vertebræ of the neck; d, From ear to ear. *2. Length and circumference of neck. 3. Breadth of shoulders. 4. Circumference of the chest. 5. Length of arm* from the wrist to the elbow, and from the elbow to the shoulder-joint. *6. Breadth of hips. 7. Extent of fork*, including the measurement below and above the knee. *8. Length of foot.* Of course the complexion, colour of eyes, &c., ought always to be stated; and phrenologists will do well, if they give also the phrenological character, stating, at the same time, whether the head is of a pure type, or how far mixed.

III. Average of measurements of 297 Scotch and Irish reapers, who were measured on the suggestion of Dr George Wilson of Edinburgh, by Charles Stevenson, Esq., Redside, Haddington.

Statement of the average Height, Weight, Complexion, &c., of Men and Women in some of the Counties of Scotland and Ireland.

SCOTLAND.

Counties.	Number.	Height.	Weight.	Colour of Eyes.	Colour of Hair.	Complexion.
		Ft. in.	st. lb.			
Roxburgh,	3 men	5 7	11 4	2 light, 1 dark	3 light	3 light
East-Lothian,	30 men	5 5	11 5	23 light, 7 dark	18 light, 12 dark	20 light, 10 dark
Do.,	19 women	5 4	8 3	17 light, 2 dark	12 light, 7 dark	15 light, 4 dark
Ayrshire,	2 men	5 9	11 5	Light	Light	Light
Wigton,	1 man	5 10	10 8	Light	Light	Dark
Fife,	4 men	5 9	11 13	3 light, 1 dark	All light	3 light, 1 dark
Lanark,	1 man	5 5	10 9	Light	Light	Dark
Do.,	2 women	5 1	10 9	Light	1 light, 1 dark	1 light, 1 dark
Skye,	8 men	5 7	10 11	6 light, 2 dark	5 light, 3 dark	3 light, 5 dark
Do.,)	5 women	5 1	9 6	4 light, 1 dark	3 light, 2 dark	1 light, 4 dark
Berwick,	1 man	5 34	8 7	Light	Light	Light
Forfar,	2 men	5 7	10 6	Light	Light	1 light, 1 dark
Aberdeen,	2 men	5 8	12 5	1 light, 1 dark	2 light, 1 dark	1 light, 1 dark
Mid-Lothian,	7 men	5 6	11 3	6 light, 1 dark	3 light, 4 dark	2 light, 5 dark
Ross,	4 women	5 5	9 9	Light	Light	Dark

IRELAND.

Counties.	Number.	Height.	Weight.	Colour of Eyes.	Colour of Hair.	Complexion.
		Ft. in.	st. lb.			
Leitrim,	31 men	5 6	10 5	29 light, 2 dark	20 light, 11 dark	8 light, 23 dark
Roscommon,	17 men	5 7	10 9	All light	13 light, 4 dark	15 dark, 4 light
Sligo,	2 men	5 5	10 2	All light	2 light, 1 dark	2 light, 1 dark
Monaghan,	6 men	5 7	10 12	All light	All light	All light
Armagh,	3 men	5 5	10 6	All light	2 light, 1 dark	2 light, 1 dark
Tyrone,	13 men	5 5	10 5	11 light, 2 dark	6 light, 5 dark	4 light, 2 dark
Down,	8 men	5 7	10 9	All light	4 light, 2 dark	2 light, 4 dark
Longford,	5 men	5 6	9 12	All light	4 light, 1 dark	3 light, 2 dark

IV. Professor James Forbes' (of Edinburgh) Tables, showing the Weight, Height, and Strength of 800 individuals belonging to England, Scotland, and Ireland.

Weights in Pounds (including Clothes).

Age.	English.	Scotch.	Irish.
15 years	114.5	112.	
16 "	127.	125.5	129.
17 "	133.5	133.5	136.
18 "	138.	139.	141.5
19 "	141.	143.	145.5
20 "	144.	146.5	148.
21 "	146.	148.5	151.
22 "	147.5	150.	153.
23 "	149.	151.	154.
24 "	150.	152.	155.
25 "	151.	152.5	155.

Height in Inches, full dimensions (with Shoes).

Age.	English.	Scotch.	Irish.
15 years	64.4	64.7	
16 "	66.5	66.8	
17 "	67.5	67.9	
18 "	68.1	68.5	68.7
19 "	68.3	68.9	69.4
20 "	68.7	69.1	69.8
21 "	68.8	69.2	70.
22 "	68.9	69.2	70.1
23 "	68.9	69.3	70.2
24 "	68.9	69.3	70.2
25 "	68.9	69.3	70.2

Strength in Pounds.

Age.	English.	Scotch.	Irish
15 years		280	
16 "	326	314	
17 "	353	340	369
18 "	364	360	389
19 "	376	378	404
20 "	385	392	416
21 "	392	402	423
22 "	397	410	427
23 "	401	417	430
24 "	403	421	431
25 "	403	423	432

Note.—It is, however, not to be lost sight of, that in these measurements no regard is paid to the *race* to which the individual belonged. Thus it would be surprising, at first sight, to see the superiority of the Irish over the English and Scotch, if we were to take them for Celts; it is, however, very well known that the Irish students in Edinburgh belong almost all of them to that part of Ireland which is inhabited by the Teutonic population.

POSTSCRIPT.—In conclusion, the author, in order to avoid misconceptions, of every kind, begs once more to state, as he has done already in his Ethnographic Map of Europe, that the results of his investigations into the origin and nature of the populations of this country, so far as they state *facts*, or lay down what the author thinks *natural laws*, are only to be considered, as scientific results, derived from a great many facts, the nature of which they *generalise*. Objections, therefore, based on individual exceptional occurrences or *facts*, can as little affect or invalidate the results stated in the notes above, as any objection, of that kind made to the splendid results obtained by *Quetelet*, which he has laid down in his excellent work "Sur l'Homme."[*] So far as the colouring of the Map is concerned, it may be objected, that the different populations cannot always be separated from each other by distinctly drawn lines, because, as is mostly the case in nature, they blend so much into each other. This the author is fully aware of. But he preferred giving a *distinct outline*—even if it should be objectionable for the reason stated—*to so overstudied accuracy in the colouring*, which gives only a confused representation of the distribution of the population, and holds out to the spectator's eye an image which, however much it may be appreciated by a profound connoisseur of the subject, necessarily bewilders and leads astray those whose object it is to *acquire* knowledge.

[*] C. & R. Chambers have published an English translation, entitled "A Treatise on Man, and the Development of his Faculties."

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